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## Value after the volcano: Economic valuation of Montserrat's Centre Hills

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# Value after the Volcano

## Economic valuation of Montserrat's Centre Hills

### Final Report

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## Abstract

As a result of volcanic activity starting in July 1995, 60% of the island was impacted severely by volcanic activity destroying a considerable amount of the forest ecosystem. The Centre Hills now comprises one of the largest intact forest areas remaining on Montserrat. The Centre Hills forest provides a number of important environmental goods and services to the people of Montserrat, which are potentially threatened. An economic valuation study of the Centre Hills has been conducted to increase our understanding of the economic importance of further conservation of the area. Three types of economic analysis conducted within the study generated the following preliminary results.

First, a *choice experiment* was used among the Montserrat population to estimate monetary values for the aesthetic, species conservation, and recreational services provided by the forest. The control of invasive species, which was also included in the experiment, was considered the most important attribute. On average, each household is willing to pay (WTP) US\$5 per month for the control of invasive species.

Second, the *Total Economic Value (TEV)* was calculated showing the relative importance of the ecosystem services from the Centre Hills forest. The tentative estimate of the TEV is around US\$1.4 million per year, with a minimum and maximum value of US\$0.9 million and US\$2 million per year, respectively. Because the Centre Hills are the only source of drinking water on Montserrat, 30% of the TEV of the Centre Hills is determined by water services. The most important value, however, is the tourism value which comprises 32% of the TEV of Centre Hills. Species abundance (18%) and forest products for domestic consumption (15%) are also highly valued ecosystem services in Montserrat.

Third, the valuation estimates were used in an extended *cost benefit analysis (CBA)* of an eradication and control programme for invasive pigs and rats in the Centre Hills. The costs include the onetime cost of pig eradication, an annual stream of lost hunting revenues after eradication and an annual stream of costs of rat control. The benefits include the onetime income generated by selling the pig meat after eradication and the annual stream of benefits to residents, which were derived from the choice experiment. However, due to a lack of information, the important value of avoided damage to biodiversity was excluded. Assuming a discount rate of 4% over a 30-year period gives a benefit-cost ratio of 0.76. Because of the exclusion of avoided damage to biodiversity, this outcome does not necessarily imply that the programme is not economically feasible. To generate a more definite conclusion about the economic feasibility, more research is needed.

## Acknowledgements

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# 1. Introduction

## 1.1 Objective

The Centre Hills are under increasing pressure for alternate land uses as Montserrat's infrastructure is being rebuilt in the North due to volcanic dislocation in the South. Moreover, new economic opportunities are being considered to develop alternative sources of income for Montserrat's residents. Income generating options relate to residential tourism and food production, which are compounded by largely private ownership with inherent rights to choice of development.

The Hills comprise the largest intact and accessible forest area remaining on Montserrat. They produce undetermined value for members of society, interest groups and the public at large whilst at the same time are shaped by these stakeholders. Many of the environmental and amenity services supplied by forests such as clean water and attractive landscapes are public goods that provide benefits to all members of society regardless of ownership. Rising "demand" for forest amenities in combination with a shrinking "supply" of forest services has created a situation in which land use conflicts may arise. Goods and services from the Centre Hills are undersupplied because they are non-priced and take long years to produce.

Given the recognised importance of the Centre Hills in providing numerous environmental goods and services to Montserrat and the presence of threats that may reduce the provision of these services, there is a need for quantitative information to guide decision making regarding management and conservation of the area. Research is needed to evaluate the economic impacts of changes in demand from exploiters of revenue generating options focussed at food and pleasure activities at national levels; to identify economically optimal solutions to prevent devaluation of good and services; and to develop public policies and management strategies to enhance the amenities. Expressing the importance of these services in monetary terms would be a first step towards designing a sustainable management plan for the Centre Hills.

Through a process of consultations with stakeholder groups, the key management issues and potential policy solutions for Centre Hills were discussed. Although a broad range of issues was identified, no one particular problem arose as a clear focus for the economic valuation study. Therefore, estimating the total economic value (TEV) of goods and services from the area in its current state, was deemed the most useful form of economic valuation information for the future management of Centre Hills.

The TEV provides a quantitative measure of how important the Centre Hills are to Montserrat in monetary terms, and functions as a reference point with which to compare possible alternative ecological states and land uses. The TEV of services from the Centre Hills therefore provides a basis for future economic valuation studies on specific impacts as they arise. For example, a TEV would facilitate research on the cost and benefits of potential developments that relate to scenarios involving the tourism and agricultural sectors.



## 1.2 Activities

To arrive at a reliable and applicable TEV estimate, which will have the support of local stakeholders, a number of steps were followed in this study. These are briefly explained in the following.

### *1. Train local staff in practical valuation techniques;*

This step involved training local members of the project team in performing all steps in designing, implementing, analysing, and reporting valuation studies. This was important for both the implementation of the current “Montserrat Economic Valuation Project” and for building local capacity to conduct valuation studies in the future. Training local staff made use of the guidelines for valuing the environment in small islands that have been developed by the team (van Beukering et al. 2007).

### *2. Gap analysis of current knowledge on ecosystem services and values.*

The project builds on existing research efforts and information on ecosystem services and their values in Montserrat (e.g. the 2006 Centre Hills socio-economic assessment). The initial step in the project was therefore to review this information and to identify gaps and limitations in the existing knowledge. In order to arrive at a comprehensive ecosystem level understanding ecosystem functions, values, and missing information, the gap analysis was conducted in collaboration with a range of experts on Montserrat.

### *3. Design economic valuation work plan.*

Based on the preceding gap analysis, the important ecosystem services provided by Centre Hills were identified and individual valuation were designed to estimate monetary values for each of these services. The selection of specific valuation techniques to be applied depended on the ecosystem services to be valued, the budget available for implementing the valuation studies (e.g. to cover survey costs), and the availability of required data (some valuation methods such as the hedonic pricing method require large datasets to be available). In addition to a plan for valuing ecosystem services under alternative scenarios for Centre Hills, this step also involved the development of an overall decision framework. The purpose of this framework is to provide a structure in which value information can be usefully compared across scenarios to inform policy decisions. As mentioned, we propose to use the TEV in which all major values will be expressed in monetary terms.

### *4. Design of development scenarios of Centre Hills.*

This step involved developing detailed descriptions of alternative development scenarios for Centre Hills. These scenarios need to describe realistic alternatives that represent the full range of options that are currently open. Omitting options from the analysis can result in the provision of incomplete information to decision makers. Scenarios should include detailed descriptions of each development path including identification of the main social, environmental, and economic impacts. Scenarios should also provide a description of the timescale over which each development path occurs. Economic modelling of current trends (e.g. economic growth, employment, water demand, visitor numbers) may be used to construct dynamic scenarios (i.e. scenarios that do not assume that the value of important variables will be the same in the future as they are in the present).

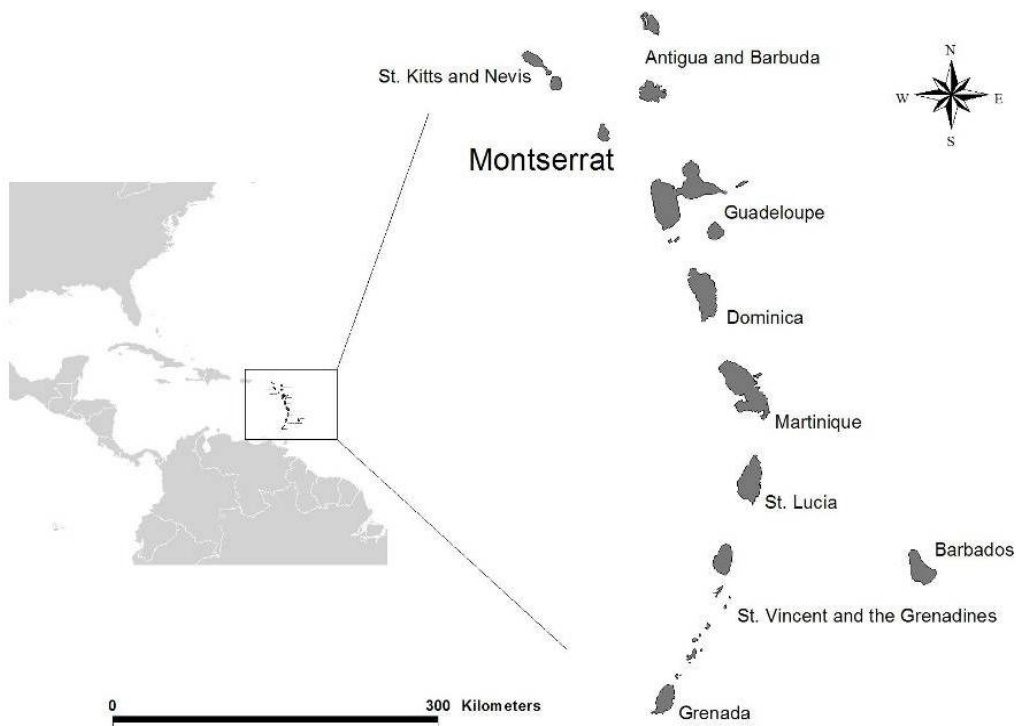
### **1.3 Structure of the report**

The structure of this report is as follows. Chapter 2 describes various aspects determining the context of the Centre Hills such as the boundaries of the Centre Hills, the environmental goods and services provided by Centre Hills, the threats currently present in the area, and a preliminary description of the current knowledge on economic values related to Centre Hills. Chapter 3 also describes the overall methodology applied to determine the TEV. Chapter 4 specifically describes the choice experiment, which was the main valuation method used in this study. The next seven chapters subsequently describe subsequent value categories. These include: recreation (Chapter 5), aesthetic quality (Chapter 6), species conservation (Chapter 7), water supply (Chapter 8), forest products (Chapter 9), tourism (Chapter 10), hazard protection (Chapter 11) and carbon sequestration (Chapter 12). Chapter 13 presents the aggregation of the individual value categories into the Total economic Value of the Centre Hills, as well as alternative scenarios. To demonstrate the role of the TEV in a cost benefit analysis (CBA), a case study on the eradication and control of invasive pigs and rats in the Centre Hills is shown in Chapter 14. Chapter 15 presents the conclusions and policy recommendations.

## 2. Context and background

### 2.1 Introduction

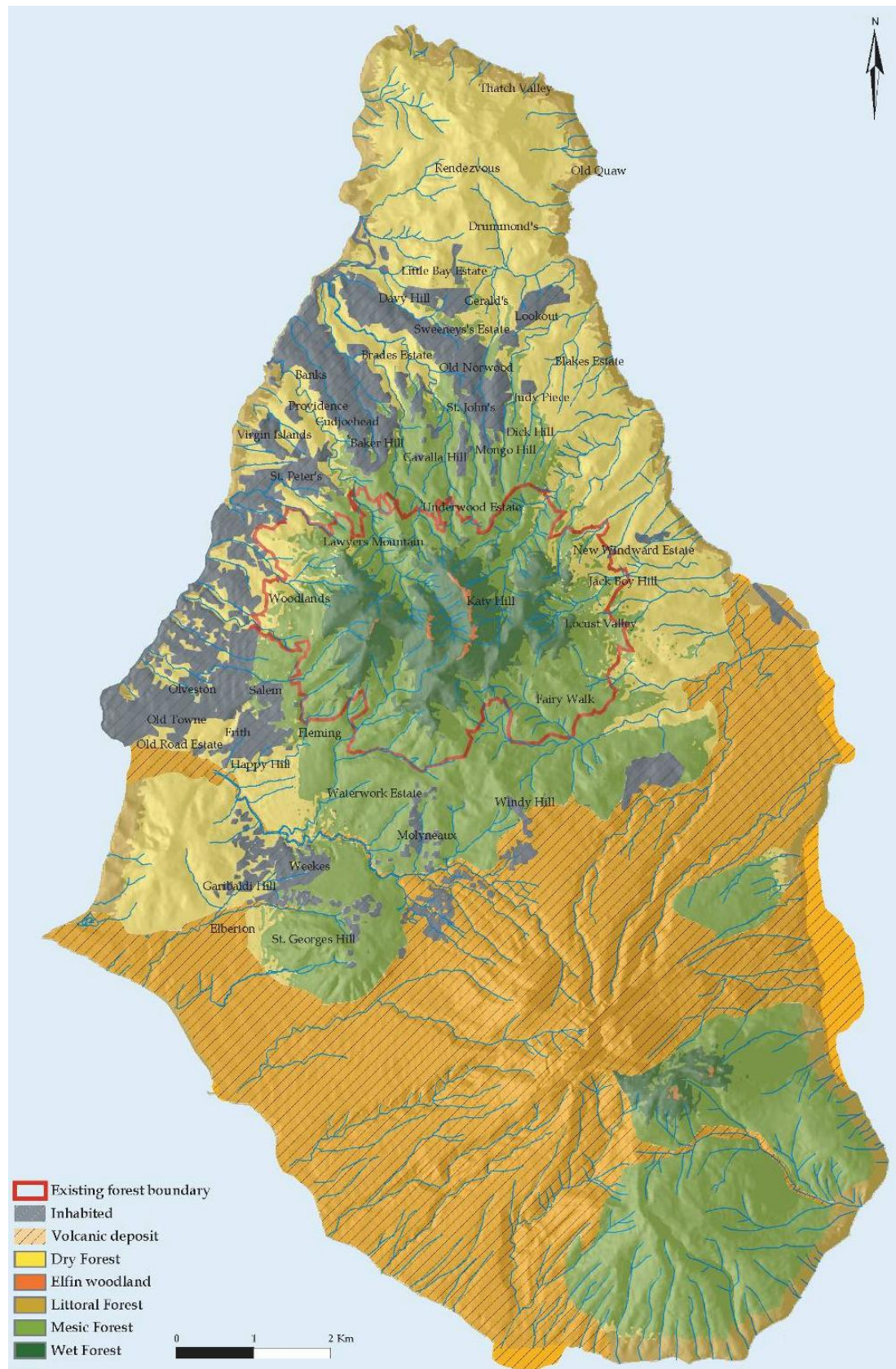
Montserrat is located in the northern part of the Lesser Antilles island arc in the West Indies (16° 45' north, 62° 12' west), between the islands of Nevis and Guadeloupe and approximately 44 km southwest of Antigua (Figure 2.1). Montserrat is approximately 102 km<sup>2</sup> in size (Young ed., 2008).



*Figure 2.1 Montserrat in the Lesser Antilles*

Source: Young ed. (2008)

The Centre Hills are located in the centre of the island. In 2000, the Centre Hills forest was given legal protection, approximately two-thirds of which is privately owned protected forest, and one-third of which is government-owned protected forest reserve. Appendix I presents the distribution of landownership within the area. The Centre Hills constitute 11.3 km<sup>2</sup> (1,130 hectares) with a perimeter of 23.8 km. This represents almost 11% of the total area of Montserrat, and 27% of the total area of the 42.5 km<sup>2</sup> “safe zone” (McCauley and Mendes, 2006). Figure 2.2 shows the vegetation map of Montserrat, indicating the forest boundary of the Centre Hills in the middle of the island. The Centre Hills are predominantly covered by mesic and wet forest, with small areas of elfin woodland at the peaks and dry forest at lower elevations (Young ed., 2008).



*Figure 2.2 Vegetation map of Montserrat*

Source: MANSAT Arnaud KEW, June 2007; RBC Kew 2007; Young ed. 2008.

## 2.2 Environmental goods and services from Centre Hills

As a result of volcanic activity in the Soufriere Hills in the southern part of the island, approximately 60% of Montserrat's forest ecosystem was destroyed. The Centre Hills now comprises the largest intact forest area remaining on Montserrat. Most of the primary forest was cleared for agriculture during the colonial era, so the current forest is largely secondary. Native trees are mixed with numerous non-native fruit trees including mangos, breadfruit and citrus.

The Centre Hills forest provides a number of important environmental goods and services to the people of Montserrat:

- *Water supply:* It is the only utilised water catchment on the island, providing a continuous supply of drinking quality water.
- *Hazard protection:* The forest also helps to prevent soil erosion, landslides and flooding during periods of severe rainfall.
- *Recreation:* The Centre Hills provides recreational opportunities for local people in terms of hiking and wildlife viewing.
- *Aesthetic quality:* It is also a source of aesthetic enjoyment and can be viewed from many parts of the island.
- *Species conservation:* The Centre Hills are the last viable enclave for most of the island's wildlife, including those of global conservation concern, such as the Montserrat oriole, Montserrat galliwasp, mountain chicken frog, and a number of endemic plants. Montserratians may hold values related to the conservation of this wildlife in terms of direct viewing of birds and other wildlife, national identity, and existence and bequest values.
- *Tourism:* The Centre Hills is also an attraction to tourists for hiking and wildlife viewing, as well as contributing to the natural beauty of the island that visitors enjoy. In addition, the area provides opportunities for scientific research.
- *Forest products:* The Centre Hills is also a source of various forest products, such as timber, fruit, wildlife etc., which are extracted by the local population.
- *Carbon sequestration:* The forest also acts as a carbon sink and thereby contributes to controlling the global climate.

## 2.3 Threats to Centre Hills

The Centre Hills faces a number of threats to its ecological and spatial integrity. Due to the scarcity of land on Montserrat, which is greatly exacerbated by the volcanic activity and resulting exclusion zone, there is pressure for other land uses to encroach on the Centre Hills forest. The main alternative land uses are agriculture and residential. This pressure is compounded by the fact that the majority of land in the Centre Hills is privately owned, and that landowners may justifiably consider the development potential for their land.

Another threat to the long-term ecological stability of Centre Hills is the growing populations of invasive species, in particular pigs and rats. These are believed to be having a devastating impact on the ecology of the forest and are major predators of native wildlife. Currently little is known of the impacts of alien invasive plants, but they are believed to be widespread.

Loose livestock may also present a threat to the ecological quality of the Centre Hills, particularly at the margins of the forest. Goats, sheep and cows that are not fenced or tied may forage in the forest and cause damage to saplings and other plants. Loose livestock is also a general problem for farmers in that it causes significant damage to crops.

Current recreation and tourism activities in the Centre Hills are generally practiced with care for the environment and have few impacts. In the long-term, however, tourism development may potentially have a negative impact on the ecology of the Centre Hills. As an area of natural beauty, and being currently undeveloped, it is a potential site for a tourism development. The construction of tourist facilities and access could negatively affect the quality and quantity of services provided by Centre Hills (e.g. species conservation, aesthetic enjoyment etc.).

### 3. Economic valuation

#### 3.1 Introduction

Nowadays, most economists agree that the value of natural resources depends not only on the market prices of its direct uses, but also on all other components of the natural resources that generate value in its broadest sense. This is reflected in the concept of the so-called Total Economic Value (TEV). This chapter explains the approach underlying the estimation of the TEV of the Centre Hills.

#### 3.2 Overall approach

The TEV is determined by following the impact pathway approach (EC, 1995) for valuing the environmental goods and services of the Centre Hills. The impact pathway approach is a methodology that proceeds sequentially through the pathway, linking causes to impacts, and valuing these impacts subsequently. Advantages of this approach are a reasonably high level of transparency, and the large potential for comprehensiveness. The framework of the impact pathway is shown in Figure 3.1 and represents the physical and socio-economic processes resulting from changes in the Centre Hills. The impact pathway approach proceeds in a series of methodological steps.

A pathway typically contains the following steps:

- Stage I: Defining the study boundaries (*i.e.* impacts on ecological functions/services);
- Stage II: Identifying the physical impacts that are economically significant;
- Stage III: Quantifying in physical terms the significant socio-economic effects;
- Stage IV: Calculating monetary values and conduct sensitivity analysis.

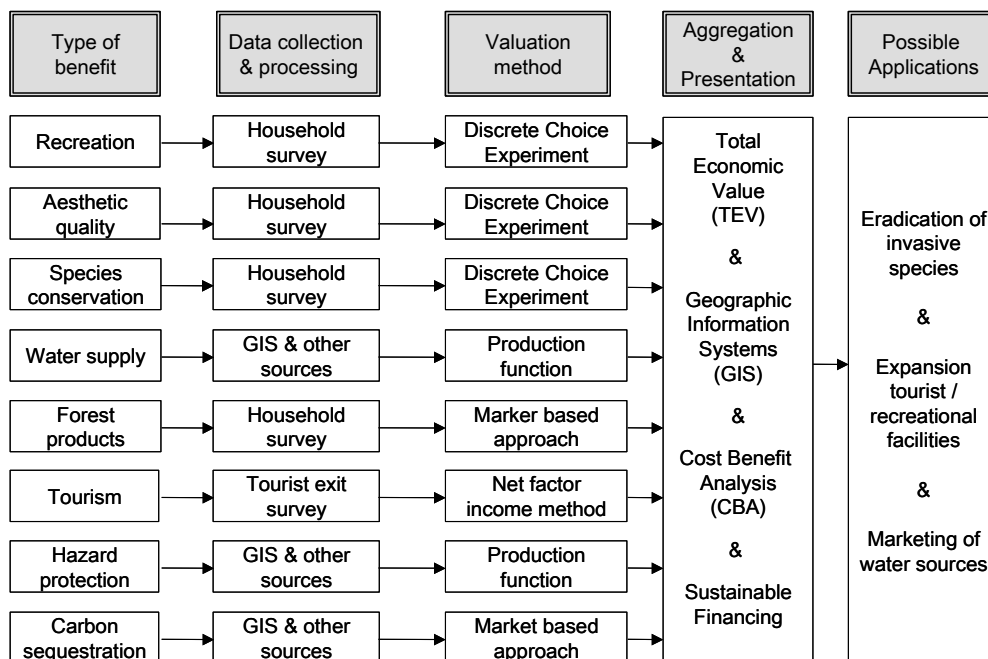


Figure 3.1 Main components of the Total Economic Value of the Centre Hills

In reality this ‘ideal’ approach can generally not be followed completely. Often there is lack of information. Some impacts can be quantified reasonably well while others can be estimated only by order of magnitude. In these cases, it is particularly important to undertake a sensitivity analysis in order to show which factors and assumptions influence overall results the most. Further, the quantitative analyses of the uncertainty can often be complemented with more qualitative considerations adding value to the overall results.

*Stage I: Defining the boundaries of the study:* To maintain a transparent and comprehensible overview of the TEV of the Centre Hills, only two scenarios are analysed. These two scenarios are: (1) sustainable utilisation, and (2) unsustainable utilisation of the Centre Hills. These scenarios are further explained in the following.

To estimate the TEV of each scenario, all project boundaries should be clearly defined. The temporal boundary of the project is set for the period 2008 to 2038. This period leaves enough time for the main environmental effects to come into effect, while it is short enough to still be able to make some prediction about future developments. The geographic boundaries have two dimensions. The boundaries of the Centre Hills are used as the area where certain policies could be addressed. The beneficiaries, however, are not limited to this area. For example, also tourist benefits arising for travel agents abroad may change as a result of changes in the Centre Hills.

*Stage II: Identifying impacts that are economically significant:* Effects may be economically significant or insignificant. Only the former category is relevant to this appraisal. Inevitably, judgement must be used in deciding what is and is not significant. In order to judge the magnitude and significance of environmental effects, a range of criteria may be identified:

- The effect on the natural, human, chemical and physical environment depending on their relative sensitivities,
- The location of the effect, whether within the confines of the site and beyond (local, regional, national and international scale),
- Timing of the effect (during the construction, operational and post-operational stage),
- Whether the effect is reversible or irreversible, and
- Whether the effect is positive or negative.

A general rule is that only first order effects should be evaluated. In other words, one would, for example, estimate and value the agricultural production loss due to the lost natural function of pest control of the rainforest. Second order effects, say, environmental and health effects caused by the increased use of pesticides due to the reduced function of pest control are ignored.

*Stage III: Physically quantifying the significant impacts:* The evaluation of the physical effects of unsustainable utilisation of the Centre Hills is a very complex exercise. Ideally, a dynamic simulation model assists in predicting the precise physical consequences of the various scenarios. As this task is beyond the scope of this project, a basic spreadsheet model has been designed. The spreadsheet model approximates the main effects of each scenario on the various benefit categories. Moreover it approximates the consequences of changes for the various stakeholders (i.e. local, national and international agents). To



calculate these impacts, simplifying assumptions have been adopted, for example, for climatic and hydrological conditions, and future economic activities.

*Stage IV: Calculating monetary values and conducting a sensitivity analysis:* Having established and tabulated the full range and significance of the effects, changes are valued in monetary terms. The main impact pathways of the different benefits will be explained in the coming chapters.<sup>1</sup>

### 3.3 Comparing TEV over time

Most projects and scenarios yield benefits at least intermittently over its lifetime, and usually they incur costs over that lifetime. Because the distribution of these costs and benefits may vary for different scenarios over time, they need to be converted to net present values (NPV) by discounting both categories of values. Discounting is the practice of placing lower values on future benefits and costs as compared to present benefits and costs, reflecting peoples' preferences for the present rather than the future. The usual way to deal with temporal effects in the analysis is to apply a discount rate to future impacts. Suppose an annual damage of the value  $X$  US\$ will occur over a period of  $T$  years, and a discount rate of  $r$  per cent is applied, then the present value of the total damage over time is:

$$\sum_{t=0}^T X / (1+r)^t$$

The present value of the damage  $X$  in any given year with  $t > 0$ ,  $X/(1+r)^t$ , is smaller than the value  $X$  in year  $t=0$ . From the equation it can be seen that the higher the discount rate  $r$  and the higher the number of years ( $t$ ), the lower the discounted value of future damage in any given year.

The choice of the appropriate discount rate remains a controversial issue because it may have a significant impact on the outcome of the analysis. The usual way to deal with this is to apply different discount rates so as to allow the decision-maker to choose the most appropriate rate. In this study we follow this practice and report values for several discount rates for the main impacts where possible.

If all effects are measured in monetary terms, the aggregation is straightforward: Simply sum the total discounted annual net benefits. This results in the TEV expressed in Net Present Value (NPV) terms:

$$NPV = \sum_t (B_t - C_t) \cdot (1+r)^{-t}$$

where  $B$  is all benefits over time and  $C$  is all costs over time. The scenario with the highest NPV is most preferred from an economic point of view. For example, if the 'sustainable' scenario generates higher discounted net-benefits than the 'unsustainable' scenario, the following condition would hold:

$$NPV_{sustainable} > NPV_{unsustainable}$$

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<sup>1</sup> To facilitate international comparison, the monetary values are expressed in US\$ using the exchange rate of December 2007: US\$1 equals XC\$2.68.

In practice, however, not all effects can be expressed in monetary units and some effects can only be assessed qualitatively. Therefore,  $NPV_{sustainable}$  and  $NPV_{unsustainable}$  can not always be directly compared. This underlies part of the variation in earlier studies investigating the NPV of rainforest conversion. Therefore, the NPV based on the quantifiable parts of the TEV should not be the sole criterion for selection. In any case, all impacts should be mentioned in an analysis irrespective of quantification or not. It is better to give a description of the impacts than having no valuation and not mentioning the impact at all.

### 3.4 Uncertainty and sensitivity analysis

There will undoubtedly be considerable uncertainty over the values of many parameters included in the analysis. It is therefore necessary to recognise these areas of uncertainty and test how sensitive the monetary valuation results are to changes in parameter values.

In the case of Montserrat there is clearly a huge source of uncertainty regarding the volcanic activity, which could dramatically affect all aspects of life on the island. Increased activity could result in a smaller habitable land area, further population decline, fewer visitors, disruption to all economic activities, and indeed directly degrade the Centre Hills. Under such a scenario, the economic value of the Centre Hills would be greatly diminished and any management of the area would be largely irrelevant. On the other hand, if the volcano becomes dormant again, the opposite would be the case. As this high level of uncertainty pervades all decision-making in Montserrat it does not seem useful to examine these extreme scenarios. We do, however, propose to examine the sensitivity of the valuation results with respect to a number of parameters that are determined within the analysis or have a broad distribution of potential values (even given stable volcanic activity). These include: population, tourist numbers, and the sensitivity of service provision to changes in forest cover.

## 4. Choice modelling

### 4.1 Introduction

Montserrat's Centre Hills generate important non-market benefits that are not easy to measure with traditional economic methods. These types of benefits can, however, be estimated using stated preference methods (i.e. contingent valuation or choice modelling) that use surveys to ask individuals about their willingness to pay (WTP) for the environmental good or service<sup>2</sup>. In this study, choice modelling is applied to determine the non-market value of local recreation, aesthetic quality, and species abundance. In addition, the method is used to assess local people's preferences for controlling invasive species such as pigs and rats in the Centre Hills.

From the end of November to the middle of December a 'choice experiment' survey was conducted among 342 local respondents. Interviews were conducted by four local interviewers. The survey consisted of three different sections. Part 1 of the questionnaire was related to people's opinion about the Centre Hills and the goods and services the forest is providing. Part 2 involved the choice experiment in which respondents were asked to choose between two future alternative options for the Centre Hills and the current situation. Finally, part 3 addressed general household information such as age, gender, education, and income of the respondents (the full questionnaire is presented in Appendix II). This information allowed for an analysis of differences in values across different socio-economic backgrounds.

This chapter provides a detailed explanation of this valuation method and presents the results of the choice experiment survey. The methodological section includes a description of the choice experiment, survey development, and the sample characteristics. In section 4.3 the main results of the choice experiment are presented. The valuation results for the three benefits (local recreation, aesthetic quality, and species abundance) are also included in the subsequent chapters that deal with each of these benefits in more detail. This chapter ends with a discussion on the choice modelling methodology and the generated results in section 4.4.

### 4.2 Methodology

#### Underlying principles

As mentioned above, choice modelling is a stated preference methodology that has increasingly been employed to analyse public preferences towards environmental goods and to estimate their economic value. Choice models are a generalised version of the dichotomous choice Contingent Valuation Method (CVM) (Biénabe and Hearne, 2006). In a CVM study, the survey environment is used to create a hypothetical market for a non-market good or service (e.g. local recreation or important species) usually by giving

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<sup>2</sup> Economic value can be measured by the amount of money an individual is willing to pay (WTP) for a good or service. An individual's WTP for a good is a reflection of his or her preferences for this good relative to other goods (Van Beukering et al., 2007).

a detailed description of the non-market benefit. In the simplest case, respondents are asked how much they would be willing to pay for a change from the current situation to a hypothetical future situation (Mitchell & Carson, 1989). However, many researchers have raised concerns about the ability of CVM studies to derive valid estimates of economic value (see Kahneman & Knetsch (1992) for a discussion of some of the limitations of CVM).

Choice modelling or ‘discrete choice experiment’ (DCE) is also a hypothetical method in that it asks people to make choices based on a hypothetical scenario. The choice modelling valuation method, however, addresses a number of the difficulties traditionally associated with contingent valuation methods. Rather than simply asking respondents how much they are willing to pay for a single improvement in a given non-market good, a choice model requires respondents to repeatedly choose between complex, multi-attribute profiles that describe various changes in non-market benefits at a given cost (e.g. a change in tax paid). As such, the choice modelling approach is useful as a tool for exploring proposed or hypothetical policy options. The value estimates from a choice model study can then be used in a decision support tool, such as cost-benefit analysis, to assess the desirability of alternative policies.

Choice modelling is generally an efficient means of collecting information, since choice tasks require respondents to simultaneously evaluate multi-attribute profiles. In addition, economic values are not elicited directly but are inferred by the trade-offs respondents make between monetary and non-monetary attributes. As a result, it is less likely that WTP information will be biased by strategic response behaviour. A further advantage of the choice experiment is that research is not limited by pre-existing market conditions, since the levels used in a choice experiment can be set to any reasonable range of values. Finally, and perhaps most importantly in the context of non-market valuation, choice experiments allow individuals to respond to non-market benefits that are described in an intuitive and meaningful way, but without asking respondents to complete the potentially objectionable task of directly assigning dollar figures to important values such as species conservation.

In a typical DCE study, respondents are presented with a series of choice sets composed of two or more multi-attribute alternatives (one alternative is often the current situation or business-as-usual scenario). For each choice set, a respondent evaluates the alternatives and chooses a preferred option. The alternative options in each choice set are described by a common set of attributes, which summarise the important aspects of the alternatives. In economic valuation studies, one of the attributes is a monetary indicator (e.g. tax), which makes it possible to calculate willingness to pay for different levels of the other attributes. Each attribute is defined by at least two distinct levels, which are varied systematically between the choice sets according to an underlying statistical experimental design plan. Values are inferred from the hypothetical choices or trade-offs that people make between the different combinations of attributes.

In the analysis of choice experiment responses, the objective is to derive a utility function that explains the value of the different attributes in the choice experiment. The importance of the non-monetary attributes relative to the monetary attribute gives the part-worth utilities of the attributes. The utility function can be used to calculate the

welfare changes resulting from different policy scenarios that are described in terms of the attributes used in the choice experiment.

For more details on the background of choice modelling, Appendix III provides a more in-depth explanation of the underlying principles of this valuation method.

### Survey development

The choice experiment survey was developed through a series of discussions with experts and pre-tests in the field. The main purpose of these activities was to identify the hypothetical scenario on which to base the choice experiment, and the most relevant attributes and levels associated with local recreation, aesthetic quality, and species abundance. These activities were also important in order to design the questionnaire in such a way that local respondents could understand each of the questions and their task during the choice experiment.

Several hypothetical or valuation scenarios for the Centre Hills were considered. The valuation scenario involves the description of a hypothetical policy decision that will be explained to survey respondents in order to set the context for the choices they will be asked to make. Possible valuation scenarios for the Centre Hills were:

1. The populations of invasive species (pigs and rats in particular) in the Centre Hills are increasing, causing damage to native species, quality of forest cover, and the hiking trails in Centre Hills. In order to pay for effective control of invasive species and to maintain and improve the quality of trails in the Centre Hills, the Government of Montserrat (GoM) is considering raising local taxes that will be ear-marked for this use.
2. Due to the scarcity of land on Montserrat, the GoM is considering allowing the development of land for housing and agriculture within a 500m fringe of the Centre Hills. This development may have negative impacts on populations of native species, quality of forest cover, and the hiking trails in the Centre Hills. The alternative option is for the GoM to purchase private land elsewhere for development, which will involve raising local taxes.

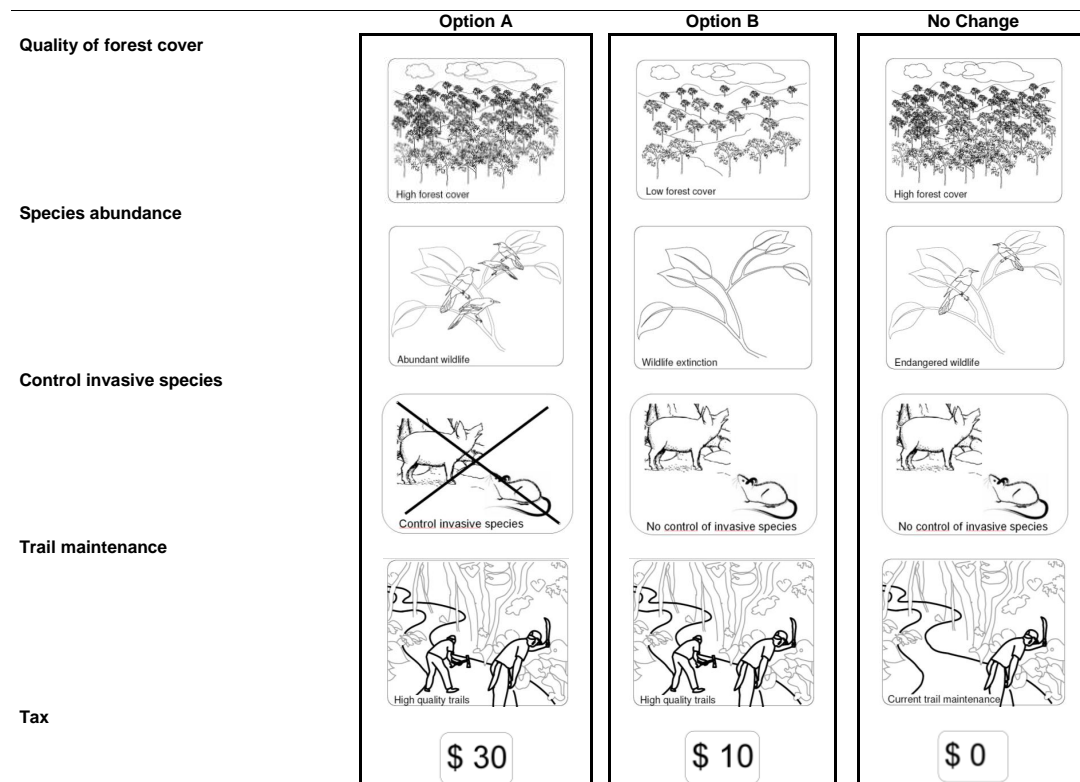
As appeared from the various discussions and interviews with local experts, both invasive species and human developments are considered to be the two main threats to the Centre Hills. Therefore, a combination of both scenarios was used as a baseline for the choice experiment. In this combined scenario, invasive species and/or human developments could result in different impacts on the Centre Hills, depending on several management options for the area. Based on this hypothetical scenario, five different attributes were defined associated with these aspects: forest cover, wildlife abundance, control of invasive species, trail maintenance, and income tax. These attributes and their attribute levels are presented in Table 4.1. The attributes and levels were then combined in different alternative options for the Centre Hills. These options were presented in choice sets, each choice set including two alternative options and the current situation. The alternative options appearing in the choice sets were derived by combining the levels of the five attributes using a fractional factorial design developed using Sawtooth SSI Web software. For this survey, the design required 32 choice sets, which were evenly divided between eight versions, i.e. each version contained four different choice sets. Each survey respondent was required to evaluate one version (i.e. four choice sets). The four in-

interviewers each used all 8 versions of the questionnaire and cycled through them (using one version per respondent). This was done to try to ensure that each version was used an equal number of times.

*Table 4.1 Attributes and attribute levels used for the choice experiment*

Attribute	Description	Levels
Natural beauty	Quality of forest cover	3: high, medium, low
Species	Abundance of wildlife	3: abundant, endangered, extinct
Invasive species	Control of invasive species	2: no control, control
Trail maintenance	Quality of trails in CH	3: high quality trails, current quality, no maintenance
Tax	Increase income tax per month	4: 0, 10, 20, 30 EC\$

The attributes and levels were presented to the respondents with pictograms to help make information processing easier. Figure 4.1 shows an example of a choice set.



*Figure 4.1 Example of a choice set*

The first option shows high forest cover, abundant wildlife, control of invasive species, high trail maintenance, and EC\$ 30 tax. The second option shows low forest cover, wildlife extinction, no control of invasive species, high trail maintenance, and EC\$ 10 tax. The third option shows the current situation: high forest cover, endangered wildlife, no control of invasive species, medium trail maintenance, and no tax. Respondents are asked to choose which option they prefer: A or B or the current situation. This means that in choosing between the options, respondents have to make a trade-off between quality of forest cover, wildlife abundance, control of invasive species, and tax. Before

showing the choice sets, interviewers explained the different attributes and levels by using a separate sheet of paper including an explanation text and all available pictograms (see Appendix II).

The interviewers were trained prior to data collection on the basic principles of the choice experiment, how to properly administer the choice experiment without introducing bias to the results, and to provide assistance to respondents in understanding the task. The pre-testing also formed part of this training. A total of 16 pretests were performed. Several adjustments were made in parts 1 and 3 in order to make the questions more understandable. For the same reason, the explanation text for the choice experiment was changed. In addition, some of the alternative options in the choice sets were considered to be unrealistic, which made it difficult for respondents to choose an alternative option instead of the current situation. For example, an option that includes low forest cover and abundant wildlife is not a realistic future option. It was also the case that some options were inferior to the current situation across all attributes, meaning that respondents were not required to make trade-offs between attributes. Therefore, several prohibitions were included in the design to prevent unrealistic or obviously inferior options being generated. These prohibitions are presented in Table 4.3.

*Table 4.2 Prohibitions included in the design of the choice sets*

Prohibition	Combination of attribute levels
1	Low forest cover + abundant wildlife
2	Low forest cover + wildlife extinction + \$ 30 Tax
3	Low forest cover + wildlife extinction + \$ 20 Tax
4	Low forest cover + wildlife extinction + \$ 10 Tax
5	High forest cover + wildlife extinction

After making adjustments in the questionnaire and the choice sets, interviewers started with the actual sampling. Research assistants working in the Centre Hills project accompanied each interviewer a number of times to check that the questionnaires were administered properly and consistently. Doubts about the consistency of the interviewing did arise, as it appeared that some interviewers finished the questionnaires in less than 10 minutes when a research assistant was not present. As the estimated time for completing a questionnaire was 15-20 minutes, this might imply that rapidly conducted questionnaires did not provide respondents with sufficient explanation of the choice tasks or enough time to consider their responses. This in turn may affect the quality of the results obtained from the choice model study. The possible impact of this or any other type of bias amongst the interviewers was examined in the analysis.

### Sample size and distribution

The target population were male or female heads of household. This included only adults, defined as persons 18 and over living in Montserrat for at least 6 months per year (McCauley and Mendes, 2006). Based on census data from 2001, this includes a number of 3,272 residents. The acceptable margin of error was limited to around 5% with a confidence level of 95%. This resulted in a desirable sample size of 330 respondents.

The sample was stratified geographically across three different areas: north (including Little Bay and everywhere north), central (Brades, Cudjoehead, Manjack) and south (St.

Peters and everywhere south). According to the census data of 2001, 45% of the population resided in the north, 20% in the centre, and 35% in the south. This resulted in the distribution as indicated Table 4.3. Within the different areas, respondents were randomly selected.

*Table 4.3 Geographical distribution of the desirable sample size*

Area	Total	Per interviewer
North	149	37
Central	67	17
South	114	29
Total number of questionnaires	330	83

After conducting the survey, 279 questionnaires provided sufficient information for inclusion in the choice model analysis. The main reason for excluding a questionnaire from the analysis was that the respondent had selected the current situation in all four choice sets that were presented to them. Due to the way in which the SSI Web software generates the statistical design of the choice sets and reads the response data, these responses do not reveal any information about the trade-offs that people are willing to make between the attributes. It is therefore not useful to include them in the choice model analysis. The characteristics of these 52 excluded respondents do not differ from those of the sample as a whole, which implies that they do not represent a particular group and that their exclusion does not change the representativeness of the sample.

Despite attempts to ensure that the interviewers use each version of the questionnaire an equal number of times, this was found not to be the case. An additional 11 interviews were therefore conducted so that each version was used at least 39 times. Table 4.4 shows the number of times that each version was used. Thus, the total survey sample size is 342 respondents, which constitutes 10% of the total population. The sample size that could be used in the choice model analysis is 290.

*Table 4.4 Number of times that each version is used (amongst 290 respondents)*

Version	Nr. of times used	Version	Nr. Of times used
1	42	5	46
2	44	6	45
3	42	7	41
4	43	8	39

The geographical distribution of the final sample size is presented in Table 4.5. As a percentage of the total number of respondents, 43% resided in the north, 22% in the centre and 36% in the south. This distribution was consistent with the 2001 census data.

*Table 4.5 Geographical distribution of the final sample size*

Area	Number of respondents	Percentage of total
North	146	43%
Central	74	22%
South	122	36%
Total	342	100%



### 4.3 Results

A detailed analysis of the household characteristics and people's perceptions on the Centre Hills (part 1 and 3 of the questionnaire) is presented in Appendix VI. This section presents the main results of the choice experiment (part 2 of the questionnaire). The data from the 290 questionnaires that provided sufficient information for inclusion in the analysis were coded in SPSS and the analysis was performed using Limdep version 7.0. A multinomial logit model was estimated using standard maximum likelihood procedures. All attributes were effects coded.

As discussed above, we have some cause for concern over the consistency of the interviewing and the implications of this for the choice model data and results. In order to test for interviewer effects we estimated the model on the full sample and then on a series of sub-samples by excluding questionnaires that had been conducting in less than 10 minutes and by excluding questionnaires conducted by each interviewer in turn. The results of this analysis showed no significant difference in estimated coefficients or statistical significance between the full sample and the sub-sample excluding those questionnaires conducted in less than 10 minutes. We did, however, find that the results changed substantially when the questionnaires conducted by interviewer 4 were excluded. This suggests that this interviewer had influenced the choices that respondents made in some way. Additional analysis of the full sample data revealed that this interviewer was also responsible for around 60% of the questionnaires in which the respondent selected the current situation four times. This provides further evidence of interviewer bias in the case of interviewer 4. We therefore decided to use only questionnaires from interviewers 1-3. This gives a sample size of 239 questionnaires.

The results of the final model are presented in Table 4.6. The coefficients represent the slope of the utility function associated with each attribute (i.e., the marginal utility per unit change in the attribute value).

*Table 4.6 Results of the Choice Experiment*

Attribute	Coefficient	Standard Error	t-statistic
Alternative specific constant	1.921	0.286	6.72
Quality of forest cover	-0.274	0.079	-3.47
Species abundance	-0.731	0.083	-8.80
Control of invasive species	0.953	0.094	10.13
Trail maintenance	-0.621	0.064	-9.66
Additional monthly income tax	0.073	0.049	1.49
<i>N</i> = 956			
<i>R</i> <sup>2</sup> adjusted = 0.21			
<i>Log likelihood</i> = -826.08			

As can be seen from the table, all attributes are statistically significant and have the expected sign. The results can be interpreted as follows:

- An option with lower forest cover is less likely to be chosen.
- An option with lower species abundance is less likely to be chosen.
- An option in which invasive species are controlled is more likely to be chosen.
- An option with lower trail maintenance is less likely to be chosen.
- An option with lower tax is more likely to be chosen.

The sizes of the coefficients reflect each attributes relative influence on the choices that were made between alternative options. It can be seen that the control of invasive species was considered the most important attribute. The information from the choice experiment can be used to calculate the relative utilities of the different attributes, or, in other words, how much of one attribute is needed to compensate for a loss in another attribute. Since one of the attributes (tax) is a monetary indicator, the marginal willingness to pay (WTP) for a change in one of the non-monetary attributes can be calculated. The marginal WTP results are presented in Table 4.7. Respondents to the questionnaire are WTP most for the control of invasive species that are present in the Centre Hills. On average, each household is WTP almost US\$ 60 (EC\$ 156) per year for the control of invasive species.

*Table 4.7 Willingness to pay for changes in forest characteristics and management*

Attribute	Change	Annual WTP per household (US\$)
Quality of forest cover	Medium to high cover	16.77
Species abundance	Threatened to abundant species	44.66
Control of invasive species	No control to control	58.26
Trail maintenance	Medium to high maintenance	37.93

In order to quantify of the uncertainty of these WTP estimates, we calculate minimum and maximum values for each attribute using the 95% confidence intervals. This gives a range within which we can be highly certain (95 times out of 100) that each WTP estimate falls. These ranges are presented in

*Table 4.8 Lower and upper bounds to annual WTP per household (US\$) for changes in forest characteristics and management*

Attribute	Lower bound WTP	Upper bound WTP
Quality of forest cover	7.31	26.23
Species abundance	34.71	54.60
Control of invasive species	46.99	69.53
Trail maintenance	30.24	45.63

#### 4.4 Discussion

Choice modelling is a useful tool for estimating non-market values such as appreciation of aesthetic quality of the forest, recreational use, and values associated with the conservation of native species. It does, however, have limitations and raise questions about the validity of the value estimates that it generates. It is worth recognising and discussing these limitations in relation to this application of choice modelling to value services from the Centre Hills.

Ideally the attributes included in a choice model should be independent of each other (both in the statistical design of the choice sets and in the perception of respondents) so that respondents can make clear trade-offs between attributes. In practice, however, it is often difficult to identify and define attributes that are truly independent. This is the case in the choice model described above. The quality of forest cover and the abundance of

species are clearly related. Respondents may have difficulty in responding to a policy option in which the quality of forest cover declines and the abundance of species improves (or visa versa). It is for this reason that we included prohibitions in the statistical design to prevent an option with high forest cover and low species abundance or high species abundance and low forest cover. Nevertheless, if respondents have made their implicit WTP decisions for one attribute based on the perception that this will also improve another attribute (e.g. improving forest cover will also help wildlife abundance), the estimated values for individual attributes may be inflated.

The control of invasive species attribute is also not independent and may also be perceived as having an impact on the quality of forest cover, wildlife abundance, recreational activities, and other benefits. As such, the WTP for the control of invasive species may be a composite of values for these other benefits. It is therefore not surprising that WTP for the control of invasive species is higher than for the other attributes.

It should be noted that WTP for the control of invasive species is based on respondents' perceptions of benefits that would result from this policy. The benefits that respondents might associate with controlling invasive species include reduced impacts on native wildlife, forest cover, recreation, tourism, and water supply. The functional relationship between the control of invasives and these benefit categories are, however, unknown. It may also be the case that respondents simply have a dislike of invasive pigs and rats in the Centre Hills forest, unrelated to any perceived damage that they cause, or that they perceive benefits from a control programme that would not in fact occur (e.g. that controlling the population of rats in the Centre Hills would reduce the numbers of rats in the urban areas). It should be understood that respondents to the questionnaire are making decisions regarding trade-offs between controlling invasive species and increased tax based on their own expectation of the benefits of control. It may be argued that peoples' expectations of benefits when information and knowledge is low is not a sound basis for estimating values. Indeed there is a substantial literature that tests for the effects of information on WTP estimates. In the case of estimating the benefits of controlling invasive species in the Centre Hills, there are no alternative sources of information other than residents' expectation of the benefits. At the very least, the choice model results provide an indication of the level of public support for a policy to control invasive species in the Centre Hills.

Another important point of discussion regarding the choice model is the use of income tax as the payment vehicle. Selecting a viable payment vehicle is a difficult issue, particularly as respondents are generally sensitive to paying for what may have been regarded as free ecosystem services. Income tax was selected because it is an existing means of revenue collection by the government that most people have direct experience and understanding of. As such it is likely to be seen as a realistic means of payment and does not require a long explanation in the questionnaire. It may, however, be the case that some of the respondents do not pay income tax themselves and therefore did not treat the payment as a relevant attribute when making choices between policy options. The majority of households on Montserrat pay income tax, so this effect is likely to be small. It should be noted that the estimated coefficient on the tax attribute is only statistically significant at around the 15% level. This is somewhat surprising given the expectation that respondents would be highly sensitive to increases in tax. It appears that

interviewer bias played a part in this outcome. Given the anticipated sensitivity of tax increases, the interviewers may have failed to fully explain the tax attribute to respondents in comparison to the explanation provided for other attributes. The significance of the coefficient on tax was shown to vary in the analysis of interviewer bias described above and improved substantially when the questionnaires from interviewer 4 were excluded from the sample.

## 5. Recreation

### 5.1 Introduction

The Centre Hills offer a number of *recreational* opportunities for residents of Montserrat. Numerous trails offer challenging hikes and wildlife observation, particularly bird watching, is possible from these trails.

### 5.2 Existing information

There are a number of existing data sources that provide useful information on recreational activities in Montserrat. First, the Centre Hills Project socio-economic assessment surveys is an important source of information on the level of use of a number of environmental services, including: the general public's perceptions and use of Centre Hills; tourist activities, willingness to pay for access, and use of guides and trails; and farming and livestock tending practices. Second, the Montserrat Tourist Board (MTB) conducted a survey of both day-trippers and over-night visitors in 2006. This survey includes questions on the role of Montserrat's natural attractions in deciding to visit the island, the main activities that were engaged in, and the amount of money spent on various services.

The survey results presented in the Socio-economic Assessment Report (McCauley and Mendes, 2006) reveals that about 20% of the surveyed general public go hiking in the Centre Hills at least once a year, some on a daily basis (2%), on a weekly basis (3%), or on a monthly basis (3%). 17% reported that they had hiked in the Centre Hills only once, twice, or a few times. Only 1% of the population reported that they had ever guided a hike for money within the Centre Hills.

In addition to hiking activities, residents surveyed reported engaging in several other recreational activities within the Centre Hills at least once a year. These include having a picnic (2%), participating in a club outing (5%), camping overnight (1%), orienteering/scouting (3%), and observing wildlife (11%). A small number of persons reported that they had engaged in some of these activities at some other time in the past or as a child. A few people reportedly walk their dogs in the Centre Hills, and some stated they just go there to relax.

According to the Socio-economic Assessment, 82% of persons felt that more hiking trails are needed in Montserrat, and 6% felt that more were not needed. 93% of the public feels that Montserrat should be promoted as an ecotourism destination.

### 5.3 Literature

There are various studies that estimated recreational values of forests. These studies use either revealed preference methods (like travel cost) or stated preference methods. Most studies that used stated preference methods to estimate (local) recreational values have been undertaken in the UK, US and Scandinavia. Christie et al. (2006) utilised both the choice experiment and contingent valuation to value a range of improvements to recreational facilities in forests in Great Britain. They found for example a WTP value of

£1.56 (\$3) per person per trip for nature trails/wildlife hides amongst general forest users. Tyrväinen and Väänänen (1998) found WTP estimates using monthly payments for the local use of three forested recreation areas ranging between 549-601 FIM/year (\$135-148). Bennet et al. (2003) estimated the value users place on access to the Ridgeway National Trail in the UK. A mean WTP was established of £1.24 (\$2.45) per visit with an estimated 150,000 visits per year (which gives an annual aggregate benefit of £186,000 (\$367,000)).

The Secretariat of the Convention on Biological Diversity (2001) gives an extensive review of the value of forest ecosystems, under which estimates of recreation values for tropical forests. The values of the reviewed literature range between \$1 and \$2305 per hectare. An example of these studies in which a stated preference method is used, is performed by Garrod and Willis (1997). They estimated the recreational values of Forest Recreation Areas (FRAs) in Malaysia at \$740/ha. In addition, Shultz et al. (1998) determined foreign and resident WTP for future visits to two different Costa Rican national parks (\$23 and \$14 vs. \$11 and \$13).

After giving some insight in the literature on recreational values using stated preference methods, it should be noted that it is difficult to suggest representative valuations since values clearly vary with location and the nature of attractions.

## **5.4 Methodology and results**

The value of local recreation in the Centre Hills is estimated using the choice experiment described in Section 4 and Appendix III. Local recreation is represented in the choice experiment by the trail maintenance attribute.

As presented in Appendix IV, 27% of the respondents of the choice experiment survey visit the Centre Hills at least once a year. It was shown that the majority of the respondents participate in recreational activities as hiking (38%) and observing wildlife (18%). In addition to these recreational aspects, 57% of the respondents agree and 30% strongly agrees with the statement that they would visit the Centre Hills more often with better trails and picnic sites.

Regarding the value of recreational access to the Centre Hills, as reflected by trail maintenance, households are WTP US\$ 38 (EC\$ 102) per year to increase trail maintenance in the Centre Hills from its current (medium) level to a high level (Table 4.7). Multiplying this amount by the number of households on Montserrat (2,082 at the last census in 2001) gives a total annual value of trail maintenance of US\$ 79,000 (EC\$ 212,000).

## 6. Aesthetic quality

### 6.1 Introduction

Many residents of Montserrat enjoy the *aesthetic quality* of the Centre Hills, which can be viewed from most northern parts of the island. Even if someone doesn't actively engage in activities in the Centre Hills they may still appreciate the pleasant views and sense of pristine environment that the forest provides.

### 6.2 Existing information

Exact data on the aesthetic quality of the Centre Hills enjoyed by the local people is not available from previous studies. The socio-economic assessment report only reveals that when respondents were asked "to what degree do you feel you have a deep appreciation for the natural environment", 49% of respondents said "a great degree", 40% said "a moderate degree", 9% reported "a slight degree", and 2% said "not at all".

### 6.3 Literature

It is difficult to provide an overview of literature estimating local values for aesthetic quality, because the motives that have been valued by different studies are not easy to distinguish. In principle, local people enjoying the aesthetic beauty of the forest is a direct use value. However, people may express WTP to conserve the forest even though they make no direct use of it. Their motive may be that they wish future generations to be able to use it (bequest value). In addition, people may be WTP for protection of the forest, simply because they wish it exists (existence value) (Van Beukering et al., 2007).

The Secretariat of the CBD (2001) gives an overview of studies that have attempted to estimate these values, most of them using stated preference methods. For example Gunawardena et al. (1999) estimate use values (0.2-0.5% of income), bequest values (0.1-0.4%) and existence values (0.2-0.3%) of the Sinharaja forest reserve in Sri Lanka. Walsh et al. (1984) and Haefele et al. (1992) find existence and bequest values of \$38 and \$82 per household for forest quality in Colorado and South Appalachians respectively (both in the US). Biénabe and Hearne (2006) used a different approach and applied choice experiments to investigate the preferences and the WTP of Costa Ricans for increased support of nature conservation and scenic beauty through a system of Payments for Environmental Services (PESs). They found that WTP values between \$0.25 and \$0.33 per month.

These studies provide some examples in which the presence and/or quality of forests is valued. However, it may be clear that literature on the use of choice experiments to estimate the direct use value from enjoying the pleasant views from the forest is very limited.

## **6.4 Methodology and results**

The value of the aesthetic quality of the Centre Hills is estimated using the choice experiment described in Section 4 and Appendix III. The aesthetic quality of the Centre Hills is represented in the choice experiment by the forest quality attribute.

Although 43% of respondents do not visit the Centre Hills, 94% enjoys the natural beauty of the Centre Hills from a distance. The fact that 38% of the respondents go hiking in the Centre Hills and 18% observe wildlife further indicates that local residents enjoy the aesthetic quality of the area.

The willingness to pay to conserve the aesthetic quality of the Centre Hills, as reflected by the quality of forest cover, is estimated to be US\$ 17 (EC\$ 45) per household per year to avoid a change from the current high quality cover to medium cover (Table 4.7).

Assuming the quality to degrade from high to low, the WTP also doubles. Multiplying this amount by the number of households on Montserrat gives a total annual value of aesthetic quality of US\$ 70,000 (EC\$ 94,000).

Montserratians clearly value the aesthetic beauty and green environment that the Centre Hills provides. The estimated value of aesthetic quality is, however, lower than the value of the other services estimated using the choice experiment. This might reflect the fact that forest cover is currently of high quality in the Centre Hills, whereas the other attributes included in the choice experiment (species abundance, trail maintenance, and invasive species) are all at less desirable levels and therefore of more concern.



## 7. Species abundance

### 7.1 Introduction

The Centre Hills supports the largest remaining tract of forest in Montserrat and consequently supports the majority of its biodiversity, including a large number of island endemic species<sup>3</sup>. It is also a key site for numerous globally threatened species. A more elaborate explanation of the biodiversity abundance in Montserrat is presented in Appendix V.

The presence of these species is of value to Montserratians for a number of reasons. Firstly, people may enjoy directly observing plants, birds and other wildlife. Secondly, some of these species, and in particular the national bird (Montserrat oriole *Icterus oberi*) and plant (*Heliconia caribaea*), provide a sense of national identity and pride. Thirdly, people may hold values related to the existence of these species unrelated to any current or future use (existence value). Similarly, people may place value on the knowledge that these species will be preserved for the enjoyment of future generations of Montserratians (bequest value).

### 7.2 Existing information

Exact data on the above mentioned values of the Centre Hills is limited from previous studies. The socio-economic assessment report reveals that 11% of the surveyed general public visits the Centre Hills to observe wildlife. On the whole, the general public felt not very knowledgeable about biodiversity; only 3% reported knowing a lot, while 58% reported knowing nothing. However, only 22% reported knowing nothing about wildlife (similar term to biodiversity) while 11% reported knowing a lot.

Participants in the general public survey were asked to identify local wildlife from a series of photos. The following summarises the findings of the photo identification questions: Most people knew the difference between the mountain chicken and the cane toad, both by sight and by geographic range. Almost 80% of persons correctly identified the mountain chicken from the photo. There appeared to be a fairly clear understanding that mountain chickens are found in the forest/mountain area. Almost 60% of people correctly identified the photo of the male Montserrat oriole as an oriole, though only half of those knew the gender. Only 47% of persons correctly identified the female Montserrat oriole as an oriole, and only 11% knew it by gender. Most people correctly stated that the orioles are found in the forest. Only 20% of persons correctly identified the galliwasp by name. 38% identified it as a lizard, snake, or combination thereof. A further 37% were unsure of its identity. Only 2% of persons correctly identified the endemic Montserrat orchid, but another 11% did recognise it as some species of orchid.

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<sup>3</sup> Endemic species are species that are unique to a particular area, e.g. Montserrat, Lesser Antilles etc. (Young ed., 2008).

### **7.3 Literature**

There are a large number of studies that estimated values related to species and/or biodiversity. Most studies have been undertaken in the UK and the US and utilise stated preference techniques. In these types of studies, biodiversity valuation can take place at four different levels: genetic diversity, species diversity, ecosystem diversity and functional diversity. The focus of this project lies at the species level; more specifically the abundance of wildlife represented by endangered species (such as the Montserrat oriole and the mountain chicken). Therefore, studies estimating values related to this level are presented here.

Nunes and van den Bergh (2001) provide an extensive overview of valuation studies that have addressed both single and multiple species. Valuations for single species range from \$5 to \$126 per household per year and for multiple species from \$18 to \$194. For example, Macmillan et al. (2002) estimated the value of wild geese conservation in Scotland, while White et al. (1997; 2001) examine the value associated with the conservation of four UK mammals: otters, water voles, red squirrels, and brown hare. The latter also examined the influence of species characteristics on WTP. They conclude that charismatic and flagship species attract significantly higher WTP values than less charismatic species. Loomis and White (1996) estimated the economic value of 18 rare, threatened and endangered species to citizens of the USA.

Scientific literature from tropical regions is limited. Turpie (2003) found that WTP for national biodiversity conservation in South Africa was \$58 million per year and increased dramatically when respondents were faced with predicted impacts of climate change on biodiversity (\$263 million). Bandara and Tisdell (2005) investigated the WTP of local households for the conservation of Asian elephants in Sri Lanka in relation to changes in abundance, ranging from \$1 to \$2 per month. Mortimer et al. (1996) underline the importance of small islands, because of high degrees of endemism among flora and fauna species. Mean WTP for conservation of Little Barrier island, New Zealand was estimated at \$37 per household.

It is clear that the assessment of biodiversity values does not lead to a univocal monetary indicator. Although the results from the different valuation studies are difficult to compare, the various results do underline the relatively high monetary values biodiversity conservation can hold.

### **7.4 Methodology and results**

The value of species abundance in the Centre Hills is estimated using the choice experiment described in Chapter 4 and Appendix III. Species abundance is represented by the wildlife abundance attribute (indicating birds).

It is likely that people outside of Montserrat will also hold existence values for some of the species mentioned above. It is, however, beyond the scope of this study to survey and estimate values for people outside of Montserrat.

As mentioned before, 18% of the respondents of the choice experiment survey observe wildlife in the Centre Hills which relates to the benefits provided by the abundance of species. In addition, a share of 92% of the respondents agrees (or strongly agrees) that endangered species (such as the Montserrat oriole, mountain chicken, Montserrat

galliwasp) should be protected no matter what the financial cost.<sup>4</sup> A share of 94% of the respondents enjoys the Centre Hills from a distance and 97% thinks that the area should be preserved for future generations, which underline the existence and bequest values respectively.

The willingness to pay for species abundance in the Centre Hills is estimated to be US\$ 45 (EC\$ 120) per household per year to change from the current situation in which unique wildlife species are endangered to a situation with abundant species populations (Table 4.7). Assuming the current situation to degrade to an even lower level at which certain species go extinct, calls for a doubling of the above WTP. Multiplying this amount by the number of households on Montserrat gives a total annual value of species abundance of around US\$ 186,000 (EC\$ 498,000). This result shows that the population of Montserrat places a high value on the existence of the island's wildlife and is willing to pay to conserve and regenerate the populations of these species.

It should be noted that this monetary value of species conservation on Montserrat only reflects the values held by the resident population of the island. It is likely that many non-residents (both Montserradians and others) value the existence and diversity of species on Montserrat. If we were able to estimate this value, the total WTP for species conservation would probably be much higher.

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<sup>4</sup> This number should be considered with caution. It is likely that not all respondents agreeing with this statement fully considered the part of the statement indicating "no matter what the financial cost". We assume however that people did relate the protection of endangered species with a trade off (e.g. costs of conservation).

## 8. Water supply

### 8.1 Introduction

Montserrat's water supply is sourced exclusively from a network of springs in the Centre Hills. There are currently nine springs providing water that is available for extraction and distribution. This water supply is of great economic importance to Montserrat. This Chapter describes and assesses the current state of land use and hydrology in the Centre Hills catchment and provides estimates of future water supply under changed land use conditions in the Centre Hills.

### 8.2 Existing information

There is one main source of information on water supply. Montserrat Utilities Ltd. (MUL), which is responsible for the provision of water and electricity on Montserrat, collect data on both the quantity and quality of water supplied from each spring. MUL have GIS maps of spring locations, pipe infrastructure, and areas that are vulnerable to landslides. MUL also monitor the amount of rainfall in Centre Hills. They are currently also engaged in a study of the hydrology of Centre Hills, although the results of this study will not be available until end 2008. In addition MUL will begin to measure evapotranspiration rates at 2 sites on the island, one of which will be in the Centre Hills.

MUL reports that water from the Centre Hills is primarily gravity-fed via pipes into a network of 18 tank reservoirs around the island. Approximately 100 million gallons per year is extracted from these sources, about 80% of which is used for public supply. Depending on the level of supply and utilisation, the remaining 20% overflows into ghauts. In 2005, the Montserrat Water Authority's (MWA) spring production network delivered 121.7 million gallons of water into its distribution system, and sold 88 million gallons. Most of the remaining 28% was released as reservoir overflow into ghauts, although a minimal amount is "unaccounted for", meaning it is lost through leaks, evaporation, percolation, etc. Springs can run from 10-15' or deeper, and recharge is dependent on gravity, soil type, and rainfall volume (McCauley and Mendes, 2006).

MWA staff visit the springs on a weekly basis to check for any signs of detrimental human or animal activity. Most of the springs and reservoirs are fenced off and therefore inaccessible to the general public. New fencing is scheduled for some of the springs within the next year.

The MWA maintains a system of water distribution pipes from Killicrankie spring, which feeds into much of the island's public supply system. The agency is responsible for maintaining the spring site from debris, livestock, and other potentially harmful intrusions. They are also responsible for some road maintenance leading up to the Waterwork pumphouse, the main point of access for foot traffic en route to the spring. Recent reports suggest that the Public Works department will soon be embarking on a road clearing exercise which would facilitate a closer access point to Killicrankie via Molyneux. This was necessitated due to the need to replace significant portions of metal

pipe following the May 20, 2006 mudflows that damaged the existing pipelines. The following table shows monthly production by major springs.

There is one water bottling enterprise in Montserrat. The water comes from the MWA distribution network of springs in the Centre Hills, and extraction volume is included in the MWA's overall figures. There have been interests over the years in new local and foreign investments in commercial water bottling. Although the most recent interest was to source water from outside of the Centre Hills in the Belham Valley, it is still of hydrological interest to the Centre Hills as they likely share the same hydrogeological platform.

With 88 million gallons of water sold, the Montserrat Water Authority (MWA) took in EC\$2,656,000 in revenue for water sales in 2005. The average tariff for water sales was \$30 per thousand gallons in 2005 and related costs were \$36 per thousand gallons. This equates to a loss of \$6 per thousand gallons to the MWA, a loss of which can be considered a government subsidy to consumers. Although this may sound bleak, it does represent a tremendous improvement from 2000 when the average tariff was \$19 per thousand gallons compared with \$43 per thousand gallons in costs, or a \$24 per thousand gallon difference between tariff and cost. Therefore, the amount of government subsidy has been reduced by three quarters since 2000. It is hoped that there will soon be no subsidy required at all as things are streamlined in the pending merger between MWA and the Montserrat Electricity Services Ltd.

As mentioned in the Forest Use section, there is one water bottling enterprise in Montserrat with an annual revenue of approximately EC\$50,000. There is currently no separate tariff for extraction or sale of water for the purposes of resale, so current sales volume is included in the MWA's overall figures. There has been interest expressed over the years to attract local and foreign investments in commercial water bottling, although a new venture is not imminent at this time. Because pipe water quality is high in Montserrat, it is speculated that any major commercial water bottling enterprise would have to be geared towards an export market where demand for bottled water is higher.

Forests play an important role in protection of watersheds. Especially on an island like Montserrat where the forest is present on steep slopes and soils are largely volcanic ash. Removal of vegetative cover could lead to high run-off and potential landslides. In addition, forests assist in the water retention in the aquifers and allow for percolation of rainwater to the aquifers feeding the springs.

### **8.3 Literature**

There is limited information in the literature on the relation between deforestation and socio-economic costs in terms of reduced water supply. The value of water supply as such, however, has been elaborately studied. Table 8.1 presents the results from contingent valuation studies of water supply from various countries. What prevails from this overview is that most of the studies estimate WTP values in the range of 1 to 3 US\$ per household per month for water supply.

Table 8.1 Contingent valuation studies estimating water-related goods

Study	Country	WTP for the following product	Average value per household per month
Howe and Smith (1994)	Boulder, USA	reliability supply	US\$ 1.5
Kwak and Russel (1994)	Seoul, South Korea	safe drinking water	US\$ 3.28
Whittington et al. (1992)	Anambra State, Nigeria	improved water supply	US\$ 0.8 – 2.1
Boadu (1992)	Rural villages, Ghana	drinking water	US\$ 0.8 – 3.8
North and Griffin (1993)	Rural villages, Philippines	water connection	US\$ 1.41 – 2.25
World Bank (1999)	Atyrau, Kazakhstan	improved water supply	US\$ 1.46

There are also a number of studies that use the replacement cost valuation method to estimate the value of ecosystem influences on water supply. Willis (2002), for example, estimates the cost of the reduction in surface and groundwater due to forests in England and Wales. The costs of these decreases in available water were expressed in monetary terms by using the estimated replacement costs in terms of the costs to water companies of increasing water supply, for example through bore-hole abstraction, treatment etc. The increased cost was found to be approximately US\$ 7.5m per year. Folke (1991) estimates the value of wetlands in maintaining both the quantity and quality of drinking water. The value of water quantity maintenance is estimated as the cost of water transport and piping water from distant sources. The value of water quality maintenance is estimated as the cost of water quality inspections, purification facilities, and nitrogen filtering.

#### 8.4 Methodology

The value of the water supply service provided by Centre Hills in its current state can be estimated as the cost of replacing this service with man-made infrastructure (i.e. using the replacement cost valuation method<sup>5</sup>). The steps involved in this valuation are:

1. Quantify the volume, quality, and reliability of supply of water currently provided from Centre Hills. This data has been provided by Bill Tonge at MUL.
2. Quantify the volume, quality, and reliability of supply of water that would be provided if the Centre Hills were heavily deforested.
3. Identify the least cost investment option for returning to the current level of water provision (in terms of quantity, quality, and reliability) from the degraded level.
4. Estimate the costs of constructing and operating the replacement infrastructure. This estimate was made using secondary data and expert consultation.

<sup>5</sup> The production function approach to valuing the environment as an input in the provision of water may be a theoretically more precise valuation method but we consider it to be impractical in this case. Data on inputs in the production of water services is limited, particularly with respect to variation in the environmental input. There is also substantial distortion in the market price paid for water in Montserrat due to government subsidies.

Ecological and hydrological models were used to relate changes in land use and forest cover in the Centre Hills to changes in the provision of the various ecosystem goods and services. Existing models for similar ecosystems have been used or adapted to represent the situation in Montserrat.

## 8.5 Results

### Climate and hydrology

Montserrat has a humid tropical climate with a wet season from around July to December, with a drier season in the intervening period. Average annual daytime temperature is around 28°C and annual rainfall varies between around 1100 mm (44 inch) a year at the coast to around 2100 mm (83 inch) at higher elevations. Large seasonal and annual variation in rainfall does occur with heaviest rainfall between September and January. Table 8.2 shows long-term monthly climatic means at Plymouth.

*Table 8.2 Climatic condition means at Plymouth*

Month	Average Sunlight (hours)	Average Temperature		Record temperature		Relative humidity	Average rainfall (mm)		Wet Days (+0.25 mm)
		Min	Max	Min	Max		am	pm	
January	7	21	28	17	32	Medium	69	65	12
February	7	21	33	17	33	High	66	61	9
March	7	21	29	17	34	Medium	65	59	9
April	8	22	30	17	34	Medium	62	59	8
May	8	23	31	19	36	High	63	60	10
June	7	24	31	19	37	High	65	63	13
July	8	24	31	21	37	High	66	64	14
August	8	24	31	21	37	High	68	66	16
September	7	23	32	19	36	High	68	66	13
October	8	23	31	19	34	High	69	66	14
November	7	23	29	15	37	Medium	70	68	16
December	7	22	28	18	33	Medium	70	67	13

There are numerous watersheds on the island that drain into ghauts, rivers and streams that empty out from all corners of the island. Montserrat's main water supply comes exclusively from a network of springs in the Centre Hills that emanate from between the face of the volcanic core and the overlying pyroclastics and agglomerates.

### Geology

Montserrat and the Lesser Antilles sit along the subduction zone between the Atlantic and Caribbean tectonic plates. In geological terms, it is a relatively young area with origin likely less than 50 million years ago. Montserrat is divided into geologic zones. The oldest area is in the south-western portion of the Centre Hills in an area now known as Bugby Hole, and is estimated at 2-11 million years old. Next in chronological age are the northern Silver Hills, estimated at 1.55 million years old and rising to a height of 403 m. The Centre Hills' highest peak is Katy Hill at 740m; their age postdates the Silver Hills, but radiometric data is not available. Farthest south, the Soufriere and South

Soufriere Hills are the youngest, geologically speaking, at 17-24,000 and 40,000 years old respectively. The tallest point is Chances Peak at 915m.

The soils are primarily volcanic in origin, comprised largely of clay and sandy loam. Much of the coastline is made up of high cliffs, with only a handful of dark sandy beaches. A narrow coastal shelf drops to over 180 m within a mile of the shore. Thus, Montserrat experiences a relatively high-energy coastline that is prone to erosion. There are no natural harbours, and only a small amount of coral reef offers shoreline protection. (McCauley, Mendes 2006)

### Water quality

The Water quality of the spring water is generally within World Health Organization levels. Water is disinfected by use of chlorinators (PHAO,1997). There are reports that some springs produce turbid water after heavy rainfall, most likely as a result of surface runoff finding it's way into the catchment chambers. Other potential hazards for contamination of the spring water are unrestricted acces for small animals or bird droppings.

### Current water supply

Montserrat's water supply is sourced exclusively from a network of springs in the Centre Hills. There are currently six springs providing water that is available for extraction and distribution. Water is primarily gravity-fed via pipes into a network of 18 tank reservoirs around the island. About 80% extracted from these sources is used for public supply. Depending on the level of supply and utilisation, the remaining 20% overflows into ghauts. A minimal amount is "unaccounted for", meaning it is lost through leaks, evaporation, percolation, etc. Springs can run from 10-15' or deeper, and recharge is dependent on gravity, soil type, and rainfall volume (McCauley and Mendes, 2006). Table 8.3 shows the monthly spring fluxes in litres as a percentage of rainfall volume in the Centre Hills. Spring water yield ranges between 1.5 and 5.8% of rainfall, depending on the season.

*Table 8.3 Monthly spring fluxes as a percentage of rainfall volume in Centre Hills catchment (mean values 2001-2006)*

Month	Spring discharge (mln L)	Rainfall (mln L)	%
January	55.7	1714.4	3.2
February	50.1	1434.4	3.5
March	54.9	940.8	5.8
April	54.8	1299.2	4.2
May	59.5	1593.5	3.7
June	51.4	1430.2	3.6
July	53.9	2409.3	2.2
August	56.5	1636.8	3.5
September	50.4	1729.4	2.9
October	58.1	3832.9	1.5
November	54.2	2864.4	1.9
December	55.4	2165.6	2.6



## Future projections

Even though currently there is no forest clearing in the protected forest area, it is useful to know what effect such a clearing would have on the provision of water for Montserrat and on the quality of that water.

A removal of the Centre Hills forest would generally result in increased overland flow and a reduction in infiltration capacity of the soil and thus recharge that is needed to sustain the flow of the springs in the area. As fully-grown forests typically use more water than other vegetation or land uses, there will be an increase in total water yield. However, because the removal of the forest will lead to decreased infiltration capacity of the soil this increased water yield will run off rather than permeate the soil to recharge the unconfined aquifer of the springs.

A thorough assessment of future possible changes in spring water yield as a result of deforestation in the area is very difficult as there is very limited information and climatic and hydrological data availability to carry out such an assessment.

To make a rough estimate of changes in spring water yield as a result of deforestation of the Centre Hills catchment, a water balance approach is adopted. Values of decreased soil infiltration and evapotranspiration under different land use conditions are taken from the literature to calculate a new future water budget for the area.

## Water balance approach

The various processes that govern stream flow production in a forested watershed can be illustrated by the watershed hydrological cycle or water budget. This can be stated as:

$$Q = P - ET + \Delta S$$

Where Q is the stream flow, P the gross precipitation (rainfall), evapotranspiration (ET) is the sum of evaporation from intercepted rainfall, evaporation from soil and water surfaces and transpiration of the forest and  $\Delta S$  is the soil water and groundwater storage change. Assuming that the soil water and groundwater storage term  $\Delta S$  represents the change in recharge of the springs, a decline in this term will lead to a decline in freshwater for the population of Montserrat. The value of the storage term under current land use conditions is taken as the total of the yearly spring fluxes from six springs in the area of which data is available converted to mm, resulting in a value of 58 mm/year. Yearly precipitation is set to 2000 mm as the Centre Hills are in the higher rainfall zone due to their elevation. The yearly evapotranspiration (ET) of the fully-grown tropical forest is in accordance with literature values (Bruijnzeel 2004, Cheng et al, 2002) assumed to be 1000 mm/year.

A conversion of tropical forest to other land use will almost always result in a decline in evapotranspiration rates. Rates of evapotranspiration under different land use in tropical conditions vary significantly but complete removal of the forest roughly leads to a decline in ET of around 250 mm and around 200 mm for conversion to pasture or plantation (Bruijnzeel, 2004). Changes in infiltration capacity of soils under forested and disturbed conditions are taken from a study in Taiwan (Cheng et al., 2002) where the infiltration capacity of the soil decreased with 75% after forest clearance and with 17% if converted to pasture. It is assumed that soil water and groundwater storage will diminish with a similar percentage. Furthermore it is also assumed that the likely increase in

surface run off as a result of the decreased evapotranspiration of the vegetation will not lead to a higher recharge of the spring water aquifers.

Table 8.4 shows the water balance for the Montserrat Centre Hills under the current land use situation and under a future land use situation where all the forest is cleared or converted into pasture.

*Table 8.4 Water balance components under different land use conditions on the Centre Hills catchment*

Water balance component	Current situation	Conversion to pasture	Cleared
Precipitation (P)	2,000	2,000	2,000
Evapotranspiration (ET)	1,000	800	750
Soil and ground water storage change ( $\Delta S$ )	0	-10	-44
Surface Runoff (Q)	800	1,190	1,206

As a result of the decreased evapotranspiration and water storage, surface runoff will increase with almost 400 mm in the case of a conversion to pasture and even more in case of a complete clearance of the forest cover. This increased surface runoff can potentially lead to floods or degraded water quality due to erosion of the soil and increased sediment loads.

The change in soil and groundwater storage means that total spring fluxes will decrease from 58.7 mm/year or 655 million litres of water to 163.5 million litres of water with a complete clearing of the forest cover and to 543.6 million litre of water with a conversion to pasture. An overview of these results is shown in Table 8.5. Changes in the watershed storage term over longer periods of time (more than 5 years) become negligible as a result of settling of the soil to the new land use situation (Cheng et al., 2002). These changes therefore take place in a relatively short period of time and after that, water yield will become stable again at a lower level.

*Table 8.5 Annual spring fluxes under different land use conditions*

Land use situation	Total annual spring flux (million litres)	Change (%)
Current situation	655.0	0
Conversion to pasture	543.6	-17
Complete forest clearance	163.5	-75

It should be realised that the estimate of change in water yield as a result of conversion of forest to other land use types is a very crude estimate. Due to the very difficult geology of the area, recharge dynamics of the springs are largely unknown. Moreover, there is little long-term data on climatic and hydrological variables. Therefore the approach of estimating changes in water yields as a result of potential changing land use in the Centre Hills is largely based on literature studies of similar situations from around the world. While there is lots of uncertainty on the magnitude of the decline in spring water yield and increase in surface run-off, the direction of the change is quite certain. A

fully-grown forest cover will always have a higher water use than any other land use types. Therefore, an increase of total water as a result of forest clearance is beyond doubt. As soil disturbance differs with the type of land use, changes in infiltration capacity of the soil differ too. However, infiltration capacity, and thus potential recharge of the aquifer is always highest with a fully-grown forest. This means that more water needs to drain as overland flow potentially leading to flooding. The effects of large scale forest removal in watersheds under similar conditions have been shown in Haiti where flash floods have led to a significant loss of lives and completely altered flow regimes.

A conversion of land use within the Centre Hills catchment to pasture or cleared land will most likely cause an increase in surface run-off and a decrease in spring water aquifers, leading to a decline in spring fluxes up to 75% in the case of complete clearing of the watershed.

### Valuation of water supply

The value of changes in the quantity of water supplied from springs in the Centre Hills has been estimated using the replacement cost approach outlined above. The volume of water provided annually from springs in the Centre Hills is 665 million litres. The actual volume used, however, is around 532 million litres per year. Under a scenario in which the Centre Hills forest is completely cleared, the volume of spring water flow is estimated to decrease to 166 million litres per year. The difference between the volume currently used and the volume provided under the deforestation scenario is therefore 366 million litres.

A potential replacement technology for water supplied from the Centre Hills is reverse osmosis desalination. This technology is used on Antigua in two desalination plants with a total capacity 3.3 million m<sup>3</sup>/year. In the following assessment of desalination costs for Montserrat we only consider the direct costs. The direct implementation costs of desalination involve construction costs and operation and maintenance cost. The indirect costs include a number of environmental impacts associated with desalination. These include increased CO<sub>2</sub> emissions, disamenities from the plant, and impacts on the marine environment through increased salinity of the discharge of other chemicals. If we were able to include these impacts, the costs of desalination would potentially be much higher.

The direct costs of implementing desalination technologies depend on a number of factors, such as the quality of feedwater, the plant capacity, the availability of land, and the costs of water distribution. Younos (2005) provides a summary of desalination costs from 23 separate studies. The unit costs range from 0.45 to 6.56 US\$ per 1,000 litres. Taking the average of these cost estimates gives a unit cost of 1.16 US\$ per 1,000 litres. Using this figure and the estimated loss in water supply from the Centre Hills under the deforestation scenario gives an annual replacement cost of US\$ 423,000 (EC\$ 1,134,000).

As mentioned above, the costs of desalination are quite variable and are dependent on a number of location specific characteristics. To give an indication of the potential range of replacement costs for water supply from the Centre Hills, we calculate values using unit costs that are 50% lower and 50% higher than the average (broadly representing the range of unit costs reported in the literature). The lower value is US\$ 211,500 (EC\$ 567,000) and the upper value is US\$ 634,500 (EC\$ 1,800,000).

## 9. Forest products

### 9.1 Introduction

A number of *forest products* are extracted from the Centre Hills including timber, wild animals, fruit, plants for the garden and medicinal purposes, materials for crafts, and animal fodder. Often the distinction is made between timber and non-timber forest products (NTFPs)<sup>6</sup>. This distinction is also used in this chapter. Although many of these products extracted from the Centre Hills are not being traded on the market, they still hold important values through their local subsistence value.

### 9.2 Existing information

Collecting wood for any reason from the Centre Hills was only reported by a few persons, and the question posed to the public in the survey did not distinguish where the actual source of materials was (whether inside or outside the forest boundary). Wood collection within the past year was reported for the purposes of charcoal production/firewood (5%), fish pot production (2%), and furniture production (less than 2%).

The general public survey revealed that 15% of residents collect fruit for personal consumption from the Centre Hills at least once a year, and 3% do so on a daily or weekly basis. Five percent reported collecting fruits for selling at least once a year, and 3% do so monthly or more frequently. A few more people reported having collected fruits in the past or as a child. Only 2% of the population reported having collected materials for crafts from the Centre Hills in the past year, and just a few more have ever done so. Persons were asked what materials are collected from the Centre Hills, and the following were reported: seeds, beads, straw, wood, bark, shells, coconut, bamboo, calabash, flowers, leaves, stones, and wool.

In terms of collecting flora for other purposes within the past year, 5% of the general public reported having collected plants for the garden, of which 2% collected on a monthly or weekly basis. At least one person reported having collected plants for animal fodder from the Centre Hills. Another 7% reported having collected plants for medicinal purposes within the past year, and about 15% reported having used plants for medicinal purposes or occasionally – though not all knew if the Centre Hills was the source of these plants. A long list of plants was generated by the public when asked what plants were used and why. Reasons for use include (both external and internal uses): refreshing drink, herbal tea, pain relief, cough suppressant, assist with regulating blood pressure and diabetes, assist with sleep, fever cleansing, baths, and poultices.

The Montserrat Arts and Crafts Association (MACA) has members who construct crafts with local materials. There does not appear to be any commercial market for collection of raw materials to supply the craft industry. It is believed that individuals either collect

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<sup>6</sup> Non-timber forest products (NTFPs) are defined here as “all tropical forest products (plants and animals, or parts thereof), other than industrial timber, which are (or can be) harvested for human use at the level of self-support or for commercial purposes” (Rijsoort, 2000).

their own materials or have a friend collect something for them. A senior citizen group has been engaged in basketry, but using imported grasses and due to the labour-intensiveness of collecting the raw materials locally. However, it is reported that prior to volcanic activity, grass collection for basketry was something that was being developed with an eye towards a commercial craft market.

Information on the value of these forest products is not provided in the socio-economic assessment report, because the market and volume of these activities are not known. Estimations were however made on hunting activities.

Only 2% of the general public reported having engaged in any form of hunting in the Centre Hills in the past year, though 8% reported having done so at some other time in life. Hunting crayfish from rivers and ghauts was reported by 5% of the population within the past year, including 3% who state that they do it on a daily or weekly basis. Almost 15% of the population reported hunting crayfish in the past or as a child. Only 1% of the population reported hunting any other animals in the Centre Hills at least once a year, though 4% said they had done so in the past. Some of these persons reported having hunted agouti and birds in the forest.

Just over 90% of the general public reported that they do not currently eat mountain chicken, though 16% reported that they had in the past. 7% responded that they eat it on a yearly basis, and 1% on a weekly basis. For those that have eaten mountain chicken, 13% got it from family or friends, 12% caught it themselves, 8% purchased in a restaurant, 5% purchased from some other source, and 1% had eaten it in Dominica. In terms of cost, 15% did not pay for it (gift or caught on own). The most common price seems to be between \$10 and \$15 per frog. Those purchasing a “dinner” of mountain chicken have paid anywhere from \$40 to \$75 for a plate which would include side dishes.

From all reports, there is only one person in Montserrat whose main livelihood is hunting for any significant source of income, and this is the only person who completed the survey. There are a handful of others who hunt mountain chickens from time to time, primarily for personal consumption rather than sale. The individual who completed the survey reports that he hunts only mountain chickens, about 10 animals per month. The hunter reports that he goes out about twice a week during several months of the year, beginning at around 7:00 pm. Sometimes there is no catch on a night of hunting, and other times he reports that he can collect 10 in a night. Therefore, his original claim to catch only 10 per month is perceived to be an underestimate. He reports selling the frogs to restaurants and private individuals, making only about \$100 per month (\$10 per frog), which represents  $\frac{1}{2}$  to  $\frac{3}{4}$  of his total income. Thus, he earns approximately \$1,200 per year selling mountain chickens.

A total of 14 restaurants were surveyed to find out about restaurant practices in selling mountain chickens. Currently, only 4 restaurants report serving mountain chicken (Grand View B&B, Tina's, JJ's Cuisine, and The People's Place). All of these restaurants report that they only prepare mountain chicken by request and when it's available, although it is known that mountain chicken is sometimes offered at some restaurants without having to request it specifically. All restaurants report that they get their frogs from the same individual mentioned above. The typical serving is a dinner plate with 2-3 frog legs at a cost of EC\$40-65 per plate. Based on reports from these

establishments, only about 64 frogs per year are sold in all of the restaurants combined. This works out to a gross income of mountain chicken dinners of just under EC\$4,800 per year, with a net income of something less than that.

It is not accurately known how many mountain chickens are collected and/or eaten by individuals outside of restaurants. Given what is known about hunting practices, it is estimated that this may be somewhere in the range of 400+ frogs per year. Due to some speculation that hunter self-reports of numbers extracted may be underrepresented, it is thought that the actual values presented here are higher. Since the industry is not regulated in any practical sense, it is impossible to determine exact amounts.

### **9.3 Literature**

Since timber is marketed, its economic value should, in principle, be easy to derive. However, in practice there are several problems involved in estimating this value such as determining the 'ex forest price' (the price received on sale to either a processor or an exporter) and the costs of transaction and transportation (Secretariat of the CBD, 2001). Gregersen et al. (1995) give insight into the methods that can generally be applied to derive timber values. Market prices are usually available for roundwood delivered at the processing plant or point of export. Costs of harvesting, extraction, and transport have to be deducted to arrive at a residual price for standing timber in the forest. Total values are derived by applying these unit prices to the estimated quantities that could be harvested as sustainable annual flows of timber from the available standing stock. It is important to mention that valuation of timber should take account of the variation in market values from species to species, and the variation in residual values with location and topography. For these reasons it is difficult to find representative case studies for Montserrat on this subject.

To give some indication on a global level, the Secretariat of the CBD (2001) indicates that the value of world trade in all timber products is around \$120 billion (gross of costs). In addition, an overview is provided of case studies where absolute profit figures are presented, including timber values for sustainable and conventional logging. Values range from \$204 to \$2,660 per hectare for sustainable practices and from \$334 to \$4,400 per hectare for conventional logging.

The Food and Agriculture Organization of the United Nations (FAO) provides the most updated information on forestry statistics. The State of the World's Forest (2007) offers a global perspective on the forest sector, including its environmental, social and economic dimensions. Montserrat is part of the Latin America and Caribbean region. The region is a major source of raw materials, but much of the processing of these materials into finished products is done in other regions. FAO (2007) also noted that the contribution of the overall forest sector to GDP is higher in Latin America and the Caribbean than in any other major region of the world. The value of forest products trade between countries has increased significantly since 1990. Exports have tripled in value for the region as a whole, mainly in South America. However, the import of forest products greatly exceeds exports in the Caribbean and Central America. In 2000, the contribution of the forest sector to GDP was approximately 2.1% for the Latin America and Caribbean region. In addition, the net trade of forest products in the Caribbean region only was around -\$1.5 billion (indicating net import into the region).

For NTFPs produced for sale, the valuation can be based on market prices, and follows closely the procedure described above for timber. However, it is likely to be considerably more difficult to apply this approach to NTFPs because of the nature of the markets involved. Most are traded locally, in markets that largely escape formal recording mechanisms, so that data on quantities and prices are not readily available. In addition, these products are used on a local subsistence basis and people acquire them not through the market but by gathering or producing the products themselves (Gregersen et al., 1995).

Much of the research on NTFPs departs from the hypothesis that commercial extraction of NTFPs can provide a stimulus to conservation and sound forest management through adding economic value to the forest, and through contributing to the peoples' cash-incomes and a country's national income and export earnings (Ros-Tonen et al., 1998). Therefore, many studies focus on the economic valuation of NTFPs (for example Gram, 2000; Godoy et al., 1993; Balick & Mendelsohn, 1992). These studies use different quantitative methods to determine the economic value of these products. These types of quantitative methods are considered to be the most accurate but depend on the time available. More qualitative methods, using interview techniques, are therefore a widely used method of obtaining data on the use and the value of NTFPs in a faster and more flexible way (for example by Begossi et al., 2002; Marshall & Newton, 2003; Philips & Gentry 1993a,b; Philips et al., 1994; Thring & Weitz, 2005).

As is the case for timber products, there are substantial difficulties in reaching general conclusions on use values, primarily because of the variety of methods used to value NTFPs. A literature review presented by the Secretariat of the CBD (2001) suggests a clustering of NTFP net values up to around \$100 per hectare per year. Pearce (1998) also analyzes a number of studies and suggests a very rough rule of the thumb of \$50 per hectare. Showing one particular case study amongst all, which comes close to a reference study for Montserrat, Balick and Mendelsohn (1992) suggest annual net revenues of \$19-61 per hectare for medicinal plant use in Belize.

It becomes clear from these differences in values that it is difficult to extrapolate these generalized values to all forests. Caution therefore needs to be exercised when doing so, mainly because values vary due to costs of access and extraction. Typically, the higher values relate to readily accessible forests and values for non-accessible forests would be close to zero (Secretariat of the CBD, 2001).

The Secretariat of the CBD (2001) also indicates that NTFP values (especially their social values) are not necessarily captured by the economic value per hectare, because the benefits of NTFPs mainly accrue to local communities. Therefore the importance of NTFPs lies more in the role they play in supporting local community incomes. It is however not possible to make generalized assumptions on this aspect, because incomes vary significantly.

#### **9.4 Methodology and results**

Estimates are provided of local market prices of the main forest products extracted from the Centre Hills and of total use values that these products provide. Local expertise, in addition to the data available from the socio-economic assessment report and the values

derived from literature, are used to generate this information. The focus lies on actual use values, not on potential values on (international) markets of products that are currently not being extracted from the Centre Hills or only on a small scale. It was outside the scope of this research to (further) investigate extraction volumes of the various forest products by using any of the above mentioned methods.

The household survey reveals that respondents are involved in several extracting activities. These include, collecting fruit (16%), collecting plants (6%), fishing (2%), collecting wood (1%) and other activities (1%). None of the respondents reports to be hunting mountain chickens. This information only underlines previous results that local residents extract a variety of forest products from the Centre Hills. In addition to the available data from the socio-economic assessment report, an overview of the main forest products and their market prices is presented in Table 9.1. A variety of forest products are traded on the local market. These products are mainly timber, fruit, flowers and animals.

*Table 9.1 Market prices of main forest products*

Product	Use	Local market price (\$XC)
<i>Timber:</i>		
Red cedar	Furniture	14.95/linear foot
White cedar	Furniture, boat building	15.00/linear foot
Black birch	Fish pot frames	25.00/bundle
White birch	Fish pot frames	25.00/bundle
<i>Fruit:</i>		
Coconut	Food	3.00 each
Mansiport/marmi apple	Food	5.00 each
Banana	Food	3.50/lb
Guava	Food	5/2.5 lb
Mango	Food (processed in drinks, jam, sweets)	3-15/product
	Food	1/each
Bread fruit	Food (processed in drinks, jam, sweets)	3-15/product
	Food	4.00/lb
<i>Flowers:</i>		
Begonias	Ornamental	25.00/floral arrangement
Heliconia	Ornamental	85.00/floral arrangement
Ferns	Ornamental	10.00/floral arrangement
<i>Animals:</i>		
Mountain chickens	Food	10/frog
		40-65/plate
Feral pigs	Food	5/lb
Cray fish	Food	25.00/lb

Although timber products are represented in the table, it should be noted that timber extraction from the Centre Hills is not permitted. Only removal of dead trees and felled trees by natural causes is allowed, which means that the extraction of timber products is very limited. Information on these extraction volumes and quantities are not available which makes it impossible to generate a total use value of timber products. Since Montserrat only imports timber, it would not be realistic to estimate timber values using substitutes of export prices from other (international) sources.



## Flora

It appears that for the extraction of fruit and flowers a local market does exist, next to extraction for personal use. In this respect, it is interesting to mention that these products hold potentials for the development of small industry. Sustainable extraction of fruit and flowers might contribute to local economy without causing serious damage to the Centre Hills. This should however be considered with caution, because underlining the value of these products and stimulating extraction could involve some negative impacts as well. Examples of this would be increased (illegal) logging of fruit trees and destruction of *Heliconia* stands, having potential consequences for forest ecology. Logging of fruit trees might impact the resource requirements of native species, such as the yellow-shouldered bat. On the contrary, the presence of fruit trees is also related to increased numbers of vertebrate frugivores, such as rats, which can cause damage to native flora and fauna species (Young ed., 2008). *Heliconia* provides both nesting sites and a source of food and water for the Montserrat oriole, which means that destruction of *Heliconia* stands might seriously impact the oriole population (pers. comm. J. (Scriber) Daly, December 2007; see also Chapter 14 on invasive species).

In addition to these products, medicinal plants seem to be used substantially, but for personal use only. The socio-economic assessment survey revealed that 7% of the general public collected plants for medicinal purposes, and about 15% reported having used medicinal plants. J. (Scriber) Daly (December 2007) states this number might be much larger and estimates the percentage of local people using medicinal plants at 80%. He often collects medicinal plants from the Centre Hills for other persons. Thus the number of people actually extracting medicinal plants and the number of people using medicinal plants is quite different. The reason for this is the fact that many people have medicinal plants in their gardens, so they have no need to extract them from the Centre Hills (pers. comm. S. Mendes, February 2008). Nonetheless, this information shows that medicinal plant use from the Centre Hills does hold important local values.

Since extraction volumes and quantities of NTFPs are not available, it is difficult to estimate total use values of these products generated by the Centre Hills. However, a rough estimate can be given using the generalized NTFP values presented in literature (see previous section). These values vary between \$50 and \$100 per hectare (including all NTFPs such as fruits, medicinal plants and animals).

To derive a total use value of fruits, flowers and medicinal plants from the Centre Hills, several aspects need to be considered. First, it assumed that actual use and extraction of NTFPs from the Centre Hills is relatively limited compared to other tropical forests where people's livelihoods often depend on the use of forest products. Second, the difficult access to (parts of) the Centre Hills make costs of transport and access to and from the area relatively high. This also means that NTFPs are probably not extracted from all parts of the Centre Hills. Finally, these generalized values also include values for the extraction of animals, but here these values are mainly applied to estimate the value of fruit, flowers and medicinal plants. The reason for this is the availability of more accurate information to calculate use values of mountain chickens and feral pigs. Thus, only Cray fish are an additional extracted animal species that should be included in these generalized estimates.

Taking these aspects into account, it is suggested to decrease the NTFP value of US\$50 per hectare derived from Pearce (1998) by 50%, using an annual value of US\$25 per hectare. This value lies within the lower range of values suggested by Balick and Mendelsohn (1992) (for medicinal plants only). This generates a NTFP value of the Centre Hills of \$ 28,250 (EC\$ 75,922) per year (the surface area of the Centre Hills constitutes 1,130 hectares (McCauley&Mendes, 2006).

## Fauna

As for the extraction of animals, the socio-economic assessment report revealed a total gross income generated by hunting of mountain chickens of EC\$ 4,800. Since the mountain chicken is listed as Critically Endangered and only lives on Montserrat, the mountain chicken represents important conservation values on both national and international levels. The local extraction value further increases its value, but this places an important threat on the species as well. Regulations and monitoring are therefore a priority conservation action to ensure hunting of mountain chickens is sustainable (Young, ed., 2008).

In addition to the extraction of mountain chicken, feral pig hunting is generating another stream of benefits from the extraction of animals. J. (*Scriber*) Daly (December 2007) states that about 15 persons are currently hunting feral pigs in the Centre Hills. He estimates that approximately 100 pigs are hunted each month. During Christmas time this number is doubled, due to increasing demands for meat. This means that the total number of pigs killed per year is around 1400. On average, pig meat is being sold for EC\$5 per pound with 70-85 pounds of meat per pig. These numbers suggest an annual income from hunting between US\$182,836 and US\$222,015 (EC\$490,000-EC\$595,000).

The above figures should however be considered with caution and are probably overestimated, because prices and weights differ and not all meat from the hunted pigs is being sold. The information was therefore verified with C. (*Blacka*) Fenton (February 2008), who indicates that the catch is about one to four pigs a trip, with trips varying between two and three times a week. This means an average number of 364 hunted pigs per year, generating an annual income of US\$ 52,631 (EC\$ 141,050). He does however indicate that there are quite a few unauthorised persons hunting as well, therefore this number might be underestimated.

It is clear that these values vary significantly. Because detailed information is not available, we use the upper bound and lower bound values to give a rough indication of the benefits that are currently resulting from pig hunting. The average of these numbers, results in an annual income from pig hunting of US\$127,528 (EC\$341,775). Finally, adding up the generated values of mountain chicken and feral pig hunting to the NTFP value estimated for all other (non-timber) forest products, results in a total NTFP value of approximately US\$ 157,648 (EC\$ 422,497) per year.

Since the estimated values of pig hunting and NTFPs are quite uncertain, we also estimate a minimum and maximum total NTFP value. The income generated by mountain chicken hunting is the same in all cases, because this value is based on relatively certain data sources. Using the minimum value of income from pig hunting of US\$ 52,631 (based on the information from C. (*Blacka*) Fenton) and decreasing the

NTFP value of \$50 per hectare by 25%, generates a minimum total NTFP value of US\$ 68,586. Assuming that NTFP values will not exceed the \$50 per hectare derived from Pearce (1998), the maximum NTFP value is calculated by using 75% of this estimate and the maximum income from pig hunting of US\$ 202,425 (based on the information from J. (*Scriber*) Daly). This results in a maximum total NTFP value of US\$ 246,710.

## 10. Tourism

### 10.1 Introduction

The Centre Hills is an attraction to tourists visiting Montserrat. The survey of tourists conducted for the socio-economic assessment revealed that a substantial proportion of visitors engage in activities related to Centre Hills, including hiking and wildlife viewing. In addition, the Centre Hills contributes to the natural beauty and tranquillity of Montserrat, which is likely to be a significant draw for most tourists. The economic value of Centre Hills related tourism is estimated as the value to the Montserrat tourist sector (i.e. producer surplus of hotels, guesthouses, restaurants, transport).

### 10.2 Existing information

Tourism is the major private industry in Montserrat, steadily bringing in between EC\$20-25 million per year since 2000. Traditionally, tourism in Montserrat has primarily been “residential tourism”, with an upscale market of clients generally staying in rental villas or guests houses for longer periods of time than the package-resort tourism that many other islands promote. There is also a modest population of expatriate home-owners who spend all or part of the year in Montserrat.

Visitor arrivals have fluctuated between 12,000 and 15,000 over the past five years. A modest decrease in arrivals and expenditures has taken place in the first 6 months of 2006. This is likely due to the shift from ferry to air service, which is felt to have had quite an impact on tourism island-wide. The current arrival rates are far less than 1995 figures when arrivals approached 20,000. However, while there has been a decrease in total arrivals since the volcanic crisis began, there has been an increase in the number of day-tripping “excursionists” versus stay-over “tourists”. This is a market that the local agencies and businesses would like to harness further. Figure 10.1 depicts changes in the number of visitor arrivals between 1995-2006.

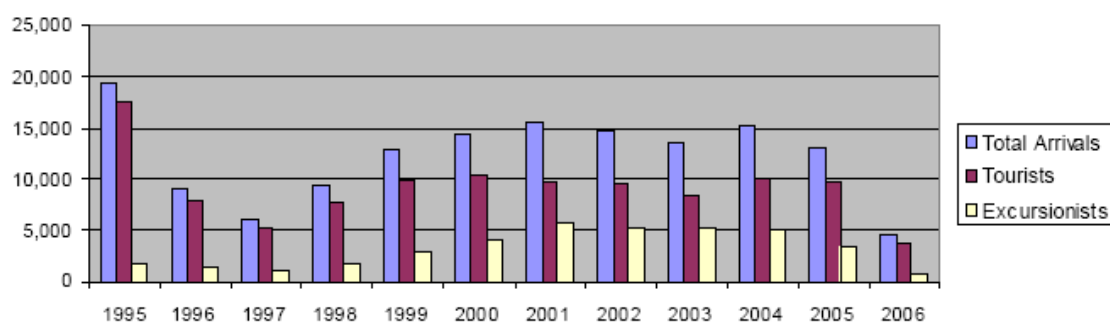


Figure 10.1 Visitor arrivals 1995 to mid-2006 (January to June 2006)

The Montserrat Tourist Board (MTB) conducted a survey of visitors (both day trippers and stay-overs) to Montserrat in the period 2006-2007. This survey includes questions on the origin of visitors, purpose of visit, accommodation on Montserrat, length of stay, what visitors considered to be the main attraction of visiting Montserrat, the main activities engaged in, and expenditures during the visit. Figure 10.2 shows the origin of stay-over visitors to Montserrat in 2007. The largest source of visitors is the UK,

followed by the US and other OECS islands. Regarding visitors that only make a day trip to Montserrat, an even larger share come from the UK, followed by OECS and the US.

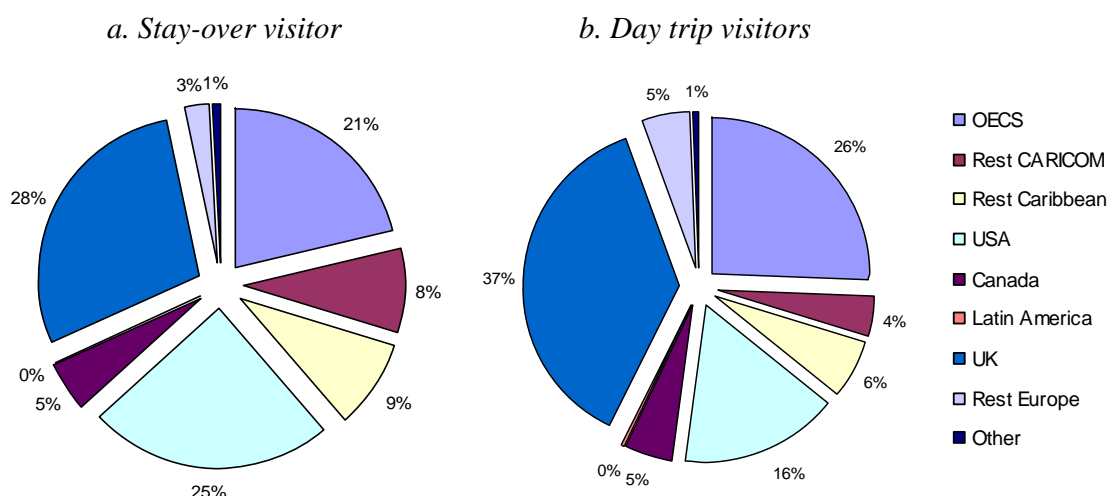


Figure 10.2 Origin of visitors to Montserrat in 2007

In 2007, a total of 7,746 stay-over visitors came to Montserrat. These people come for a number of reasons, including for holiday, to visit friends and relatives, and for business. Figure 10.3 shows the number of visitors and the purpose for which they visited in 2007. A large majority visited for leisure purposes, with roughly equal numbers coming to visit friends and relatives or for business reasons.

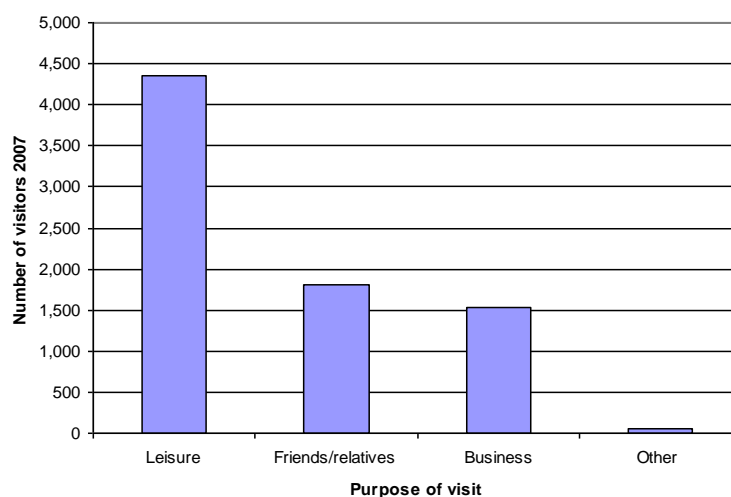


Figure 10.3 Purpose of visit for stay-over visitors (MTB visitor survey, 2007)

Visitor expenditure in tourism rose from EC\$19 million in 1995 to EC\$24.3 million in 2005. A low was reached in 1997 with expenditures of just EC\$11.9 million, likely due to the severe volcanic activity that year. Since 1998, expenditures have fluctuated to some degree, but remaining over EC\$20 million per year. Data from 2005 and the first half of 2006 indicate significant decline in arrivals and expenditure. This may be attributable to the shift from ferry to air service. In 2005, arrivals totalled 13,085 and in the first half of 2006, arrivals totalled 4,612. The decline in tourism activity is apparent also in terms of tourist expenditures; EC\$10.8 million was spent from January to June 2006 while EC\$24.3 million was spent during the entirety of 2005.

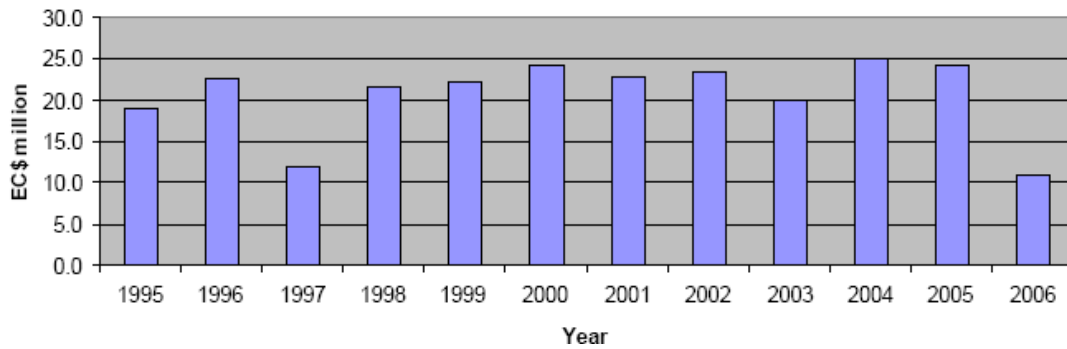


Figure 10.4 Visitor expenditure 1995 to mid-2006 (January to June 2006)

During the socio-economic assessment, a more elaborate exit survey was conducted among 204 respondents at the airport in the period December 2005 to July 2006. An additional 220 exit surveys were gathered until November 2007 with a slightly altered questionnaire (see Appendix VII). The results of the total 424 surveys were analyzed by the EVP (see below).

### 10.3 Literature

There exists an extensive literature on the economic value of forests in providing tourism services. These valuation studies cover a wide range of forest types and valuation methods. A few examples are described here. Adger et al. (1994) use a travel cost approach to estimate the tourism value of forests in Mexico at US\$ 32 per hectare per year. Ellingson and Seidl (2007) used two stated preference valuation methods (contingent valuation and contingent behaviour) to measure visitor's willingness to pay for improved tourism services at a forest reserve in Bolivia. They found that mean willingness to pay from the two methods employed resulted in widely different estimated values (US\$ 37 for CV and US\$ 77 for CB). Hearne and Salinas (2002) used a choice experiment approach to examine tourist preferences for the development of the Barva Volcano area in Costa Rica. The results indicate that preferences of foreign and Costa Rican tourists are generally similar. Both groups prefer that the site be developed to offer more information, better views, and more modern infrastructure.

### 10.4 Methodology

The net factor income method was used to estimate producer surplus from Centre Hills related tourism. This valuation involves the following steps:

1. Calculate the total revenue generated from Centre Hills related tourism. Data from the Montserrat Tourist Board (MTB) 2006 visitor survey was used to calculate total expenditures. The purpose of most tourist visits to Montserrat is to experience multiple attractions of the island, with Centre Hills being one of a number of attractions. It is therefore necessary to estimate the proportion of revenue that can be attributed to Centre Hills. This was done by using information from the exit visitor survey on the role that various attractions played in making the decision to visit Montserrat and/or activities people engaged in during their visit.
2. Calculate the profit factor of providing tourist services. This was done using a small survey of guesthouse owners.

3. Calculate the net factor income by multiplying the revenues generated from tourism by the profit factor.

## 10.5 Results

### Tourist expenditures 2007

In 2007, tourists spent an estimated total of around EC\$ 20 million on a range of expense items including accommodation, food, transportation, and shopping. Figure 10.5 presents the average expenditure per visitor across different categories of expenses. By far the largest expense item for the average tourist to Montserrat is accommodation, followed by food and drinks, and transportation. Given that the total number of tourists to Montserrat in 2007 was 7,746, the average expenditure per visitor was EC\$ 2,595. The average length of stay for tourists to Montserrat is 10.6 days, which means that on average tourists spend XCD 245 per day.

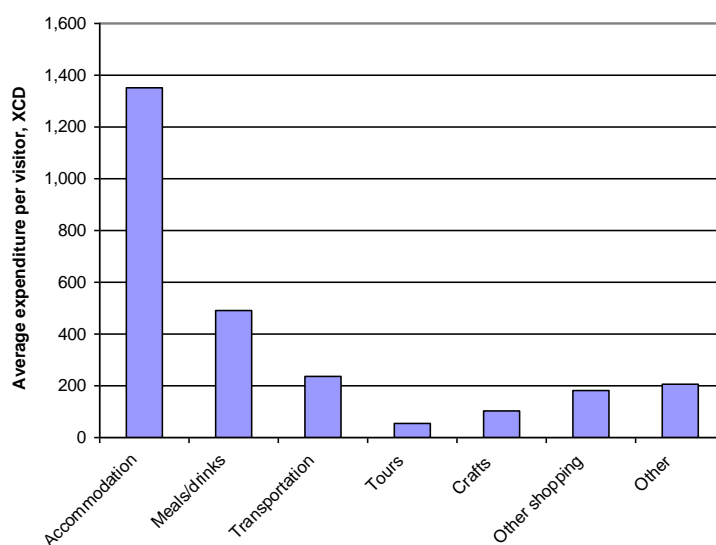


Figure 10.5 Average expenditure per visitor (MTB visitor survey, 2007)

### EVP Exit survey – general information

To provide a brief respondent profile of the visitor sample of the exit survey, 22% were travelling alone, 45% were travelling in couples, and the remainder were in larger groups – some as large as 22 persons. The respondents' primary residence was the USA (46%), the UK (27%) and Canada (12%). 3% of respondents were residents from the Caribbean and 12% from other parts of the world. A total of 47% of respondents had spent less than a week in Montserrat, another 37% had spent 1-2 weeks, 10% had spent 2-4 weeks, and 6% had spent more than 4 weeks.

Based on data from visitors completing the airport exit survey who reported using one or more of the trails, the most popular trails were Rendezvous Circle and the Oriole Walkway, followed by The Cot, Runaway Ghaut (see Table 10.2). The major sources of information about trails came from the internet (31%), family/friends (26%) and previous visits (14%). Brochures, newspapers and TV coverage are the least relevant sources of information on the trails in Montserrat.

*Table 10.1 Relative popularity of trails in Montserrat*

Trail	Share
Rendezvous	20%
Oriole Walkway	18%
The Cot	15%
Runaway ghaut	13%
Other	10%
Jack Boy Hill	8%
Duberry/Cassava	7%
Blackwood Allen	6%
Katy Hill	4%

Only 12% of survey respondents reported having hired a trail guide. Sources of guides included the Montserrat National Trust, Montserrat Tourist Board, hotels, taxi/tour guides, travel agents, or via other word-of-mouth. Trips varied between two and seven hours. People paid various rates for trail guides, ranging from US\$ 5 to US\$ 100 per head (with an average of US\$ 34)– although varying fees include other tours, meals, transportation, etc. Thus, from the information gathered, it is difficult to determine how much revenue actually went to the guides themselves.

Additional information about visitor behaviour was collected as part of the tourism survey. People were asked to state their major and minor reasons for coming to Montserrat. These motivations were analyzed by assuming that major reasons were three times more important than minor reasons. From this information, the relative importance of people's motivation was calculated. Major reasons weigh three times more in the aggregate "motivation" indicator than minor reasons.

As can be seen from Table 10.2, the three main reasons for coming to Montserrat included viewing the volcano, visiting friends/family and enjoying the natural environment. Around 32% of people's motivation is related to the Centre Hills (i.e. enjoying natural environment, wildlife viewing and hiking).

*Table 10.2 Motivation for visit to Montserrat*

Motivation for visit	Importance
Volcano viewing	20%
Visit friends/family	16%
Natural environment*	15%
Uncrowded destination	13%
Wildlife viewing*	9%
Hiking*	7%
Snorkeling/SCUBA diving	6%
Work/business	4%
Own property	3%
Other reason	7%

\* Centre Hills related activities/motivations



Appreciating that the majority of visitors to Montserrat engage in some sort of environmental activity in the Centre Hills while they are here, it is obvious that the Centre Hills are linked to tourism revenue in a significant way. Even if not being primary reason for coming to Montserrat, 52% of the respondents of the tourism survey reported that they had gone hiking during their visit and 42% reported wildlife viewing as one of their activities (see Table 10.3).

*Table 10.3 Activities on Montserrat by average visitor*

Activity	Activities per person	Relative importance
Going to beach	0.70	16%
Visit MVO	0.68	16%
Visit MNT	0.55	13%
Hiking	0.52	12%
Visit DTEZone	0.49	11%
Wildlife viewing	0.42	10%
Snorkeling/SCUBA diving	0.32	7%
Shopping	0.26	6%
Jack Boy Hill view platform	0.23	5%
Sailing	0.04	1%
Fishing	0.03	1%
Other	0.10	2%
Total	4.34	100%

In terms of what types of recreational services and/or facilities that visitors would like to see (provided or improved), many suggestions were made. These results are presented in Table 10.4. The majority of respondents (36%) reported that they would use self-guided hiking trails in a national park. This is followed by public restrooms (26%), wildlife viewing platforms (23%) and picnic facilities (21%). Other reported services included for example mountain biking, horseback riding and golf. It is also important to note that several people commented that they would prefer to not have any services or amenities, but to keep things in as natural a state as possible – or at least not to “overdevelop” facilities. On the other hand, developing such services might attract more tourists to the Centre Hills and thereby generate more revenues.

*Table 10.4 Recreational services/facilities that visitors would use in a national park in Montserrat*

Recreational services/facilities	Share
Self-guided hiking trails	36%
Public restrooms	26%
Wildlife viewing platforms	23%
Picnic facilities	21%
Interpretation centre	17%
Food concession	13%
Guided hiking trails	12%
Overnight camping	9%
Other	8%

### EVP Exit survey – Willingness to Pay

When asked how much they would be willing to pay per day for entrance to a national park in Montserrat when improved amenities would be provided, 82% of tourists surveyed responded. Figure 10.6 shows respondents' WTP per proposed entrance fee. On average, respondents were WTP US\$ 10 per day. Most of the respondents (35%) are WTP US\$ 10. Only 4% said they would pay US\$25. Around 11% of respondents are not willing to pay at all.

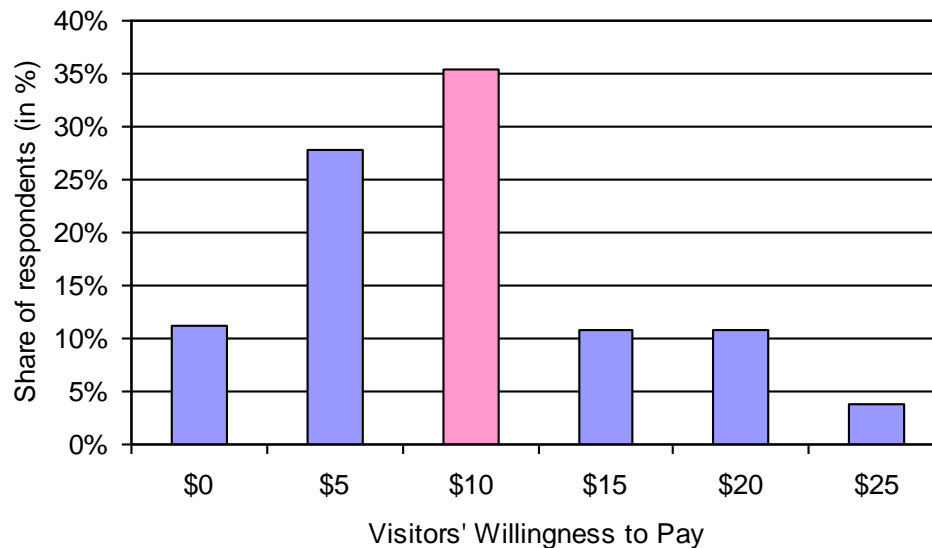


Figure 10.6 Visitors' Willingness to Pay for entrance to a national park in Montserrat

The WTP estimates vary across the sample, depending on various aspects. First, nationality is an important variable influencing the level of WTP. People from the UK and other EU countries were willing to pay US\$11.5 and US\$9.5, respectively. Second, as shown in Table 10.5, WTP is negatively related to the length of stay. The day-trippers have the highest WTP while those visitors that stay one month or more reveal the lowest WTP. This is plausible given the fact that these long-term visitors prefer not to pay with each visit to the Centre Hills. Third, WTP varies between visitors that use a guide and those that go hiking independently. The former group clearly has a higher WTP (US\$12.1) compared to the latter group (US\$9.4).

Table 10.5 WTP for visitors with varying length of stay

Length of stay	WTP amount (US\$/person/visit)
0 to 1 day	11.1
2 to 3 days	9.8
4 to 7 days	9.1
1 to 2 weeks	10.5
3 to 4 weeks	8.4
1 to 3 months	7.9

### Producer and consumer surplus

Using the figure of 32% for the proportion of tourists that visit Montserrat primarily due to the Centre Hills, we calculate that EC\$6.4 million (US\$2.4 million) of tourist revenues can be attributed to Centre Hills. In order to calculate the producer surplus gained from tourism on Montserrat (i.e. the profit made by suppliers of tourism services) we subtract the cost of providing tourism services. No statistics of costs in the tourism industry on Montserrat are available, so we use a value added factor of 15% based on a small sample of operators in the industry. This results in a net factor income from Centre Hills related tourism of almost EC\$1 million (US\$360,000) per year.

The consumer surplus is based on the WTP determined in the exit survey. The average WTP per visitor was determined at slightly over US\$10 per visit. Multiplying the 7,746 visitors times the average WTP results in a consumer surplus of EC\$240,000 (US\$89,150) per year.

### Research

The Centre Hills provides a valuable resource for scientific research and attracts a significant number of researchers. Visiting scientists have been coming to Montserrat for many years to study various plants and animals. In addition, the Montserrat Volcano Observatory staff occasionally use forest trails to access survey and monitoring points in the southeast part of the Centre Hills.

The value of research activities in the Centre Hills is valued in a similar way to tourism using the net factor income method to estimate producer surplus from providing services to researchers.

The CHP socio-economic survey estimated that Centre Hills related researchers spent 609 person-days on Montserrat in the 21 months between January 2005 and September 2006. On an annual basis this is 348 person-days. Using the same estimated daily expenditure as for tourists, the total annual expenditures by the Centre Hills researchers is EC\$ 85,184. The net factor income from the Centre Hills related research is therefore approximately EC\$ 13,000 (US\$5,000) per year.

### Aggregation of the tourist value

Combining the producer surplus, the consumer surplus and the research value results in a total tourist value of EC\$1.2 million (US\$448,514) per year. Assuming a lower Centre Hills dependency of tourism (i.e. 20% instead of 32%) leads to a minimum value of EC\$844,000 (US\$313,751). Assuming an increase in tourist numbers to the previous levels (i.e. 10,000 visitors instead of 7,700 visitors) results in a maximum tourism value of EC\$1.6 million (US\$579,027).

## 11. Hazard protection

### 11.1 Introduction

The Centre Hills, in its current state of high forest cover, provides protection from landslides by effectively binding the soil and preventing rainwater from destabilising steep slopes. The value of this service can be estimated by calculating the avoided damage costs from landslides that would occur if the forest were degraded.

### 11.2 Literature

Large (>3m) landslides not so much influenced by the presence or absence of a well developed forest cover but rather by the geological, topographical and climatic factors. However, the presence of a forest cover is important in the prevention of shallow landslides (< 1m) because of the mechanical reinforcement of the soil by the tree root network (Bruijnzeel, 2004). Land slides occurrences are common in the Caribbean, particularly in heavily degraded areas. For example in Haiti, where landslides as a result of land degradation have resulted in the loss of hundreds of lives in the last few years (UN, 2004).

Estimating the increased risk of landslides as a result of deforestation is very difficult and depends heavily on climate, geology and land use. A recently developed landslide risk rating system (Saldivar Sali, 2007) uses standard hazard contributing factors such as vegetation type, bedrock geology and slope gradients and risk contributory factors to determine the risk of landslides. The risk contributory factors are land use and population and these are used as multipliers in the risk assessment. Assuming that none of the standard hazard factors will change when the forest is cleared, the different land use multipliers can be used to assess a percentual change in landslide hazard. Table 4.5 shows the land-use multipliers for different types of land use. A conversion from forest to agriculture would therefore mean a 10% increase in risk of landslides.

*Table 11.1 Land use multipliers used for landslide risk assessment*

Land use	Land-use multiplier
Built-up	1
Grasslands	0.95
Agriculture	0.9
Miscellaneous	0.85
Forest	0.8

Source: Saldivar Sali, 2007

Under undisturbed forested conditions, suspended sediment yields in small tropical catchments are typically in the range of 3-5 tons per hectare. However, it is shown that forest conversion to agriculture in volcanic upland areas has lead to suspended sediment yields of up to 55 tons/hectare per year (Bruijnzeel, 2004). This means that a conversion to agriculture could potentially lead to an increase in suspended sediment yield of around ten times that of the current situation.

### 11.3 Methodology

The steps involved in this valuation are:

1. Identify the location of possible landslides in the Centre Hills. Maps are available from DMCA.
2. Estimate the probability of landslides occurring in the Centre Hills in its current state.
3. Estimate the probability of landslides occurring in the Centre Hills if there were a high degree of deforestation.
4. Identify the infrastructure (e.g. water pipes, roads, telephone cables etc.), agricultural land, and properties that could be impacted by landslides.
5. Estimate the cost of potential damage to these assets (i.e. the cost of replacing or repairing them). Cost information was obtained from MUL for water pipes and Public Works for roads.
6. Estimate the value of protection as the difference between the expected cost of damage (i.e. probability multiplied by cost) under the current situation and the degraded forest situation.

### 11.4 Results

Roads and other infrastructure relevant in the context of hazards may not fall exactly in the Centre Hills, but are located on the out skirt of the region. Specific information on roads and other infrastructure that are vulnerable to landslides in Centre Hills was retrieved from the Public Works department. Specific information is available on the location of the roads, the road category, its length and its surface type. Public Works informed us that, due to the mountainous nature of the Montserrat, the majority of existing roads are constructed by cutting into the hill sides, making them vulnerable to landslides (see **Error! Reference source not found.**). However, many methods such as retaining walls, proper sloping of the embankment and drainage are use to mitigated the likelihood of landslides occurring.

There is limited information on the costs of replacing or repairing roads and other infrastructure damaged by landslides. More generally, it was estimated that for 2007 cost for routine and cyclic maintenance of 102 kilometres of roads in Montserrat is approximately EC\$1,800,000. These roads are shown in Figure 11.1.

As shown in Table 11.2, three types of roads are present, each requiring different levels of maintenance. On the basis of expert judgements, we attached weights to each category, representing the maintenance intensity of the respective road types. By multiplying the length and the maintenance intensity, we determined the relative share in the total maintenance costs of each road type, allowing calculating the maintenance costs per kilometre for each road type. These unit cost estimates in turn allowed for the calculation of the total maintenance costs for roads in and around Centre Hills. These costs for Centre Hills' roads come to more than EC\$450,000 (US\$170,000) per year.

Table 11.2 Land use multipliers used for landslide risk assessment

Variable	A roads	B roads	C roads	Total
Length roads Montserrat	23 km	6.4 km	73.4 km	102 km
Cost factor	4	2	1	7
Cost factor * length	92	12.8	73.4	178.2
Costs per road type	EC\$ 929,293	EC\$129,293	EC\$741,414	EC\$1,800,000
Cost per km	EC\$40,404	EC\$20,202	EC\$10,101	
Length roads Centre Hills	8 km	n.a.	13 km	
Costs Centre Hills	EC\$323,232	-	EC\$131,313	EC\$454,545
Costs Centre Hills	US\$120,609	-	US\$48,997	US\$169,607

From the literature, it was estimated that clearing of the forest for alternative land use like agriculture could lead to an increase in landslides with 10% and an increase in suspended sediment in the water of around ten times that of the current situation. On the basis of expert interviews, we assume that the maintenance costs and landslide occurrence are more than proportionally linked. In other words, with an increase of landslides of 10%, the maintenance costs will increase by 20%. On the basis of this assumption, we calculate the Centre Hills currently perform a hazard protection role of EC\$90,909 (US\$33,921) per year. Minimum and maximum hazard protection values are EC\$45,454 (US\$16,960) per year and EC\$136,364 (US\$50,882), respectively. Note that many of the underlying assumptions are not based on empirical evidence but on expert judgements, and therefore need further investigation.

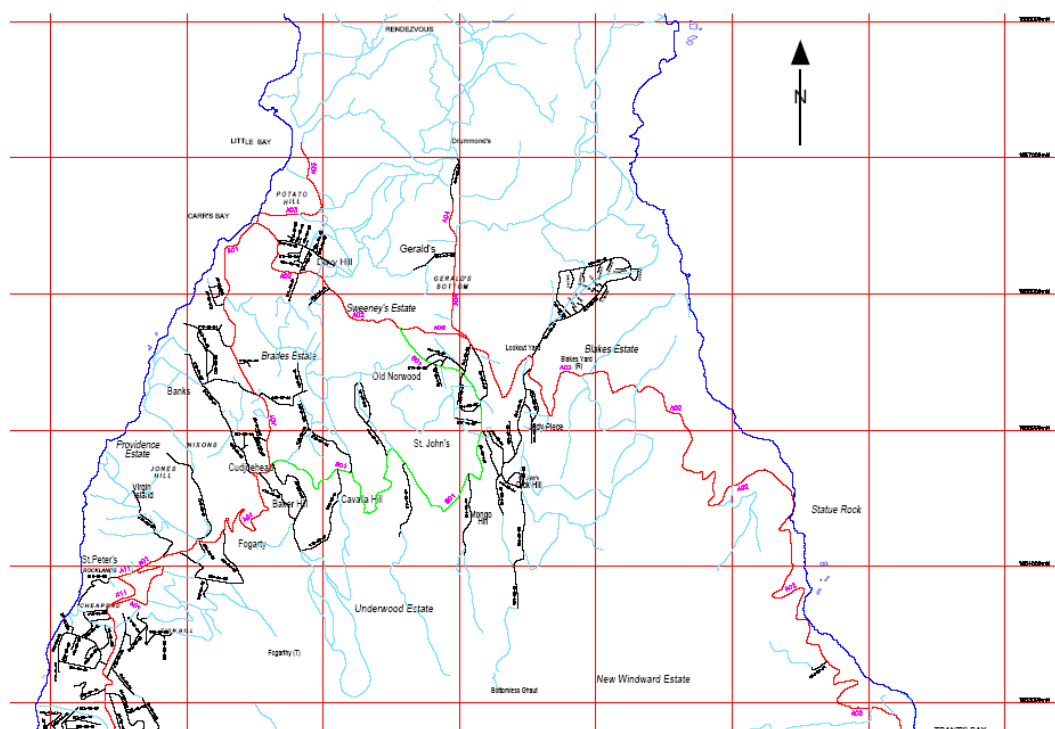


Figure 11.1 Road maps of Montserrat

## 12. Carbon sequestration

### 12.1 Introduction

Forests form an important store of terrestrial carbon and are thus considered an highly relevant ecosystem in the debate on climate change (Landell-Mills & Porras, 2002). Approximately 50 percent of tree dry weight is made up of carbon. Tree growth therefore sequesters carbon, continuing until the tree is mature and a natural equilibrium is established. However, forests are also a source of carbon dioxide. Every year a huge amount of carbon (estimated at 125 gigatons) is exchanged between vegetation, soil and atmosphere. Forests account for about 80% of this exchange, but deforestation has disrupted the equilibrium between emission and uptake, accounting for 20-25% of the enhanced greenhouse effect. Therefore, the forests of Centre Hills may also have an economic value in terms of storing carbon.

### 12.2 Background knowledge

The United Nations Framework Convention on Climate Change (UNFCCC), held 1992 in Rio de Janeiro, was established to create a regulatory framework to combat climate change. The Kyoto protocol, which saw the light in 1997, furthered the development of a carbon market by establishing quantified emission reduction targets for industrialized (Annex B) countries (Landell-Mills & Porras, 2002). It also provides a framework for trading carbon offsets.

Forests can generate carbon offsets by a number of approaches. These are reforestation and afforestation; improved forest management; conservation and protection of existing forests (i.e. avoided deforestation); and bio-fuel production (WRI, 2001). During the 2001 COP7, held in Marrakech, it was agreed to limit forestry under CDM to afforestation and reforestation only. Averted deforestation projects will be considered for future commitment periods (Niesten et al., 2002), (Smith & Scherr, 2003). In the mean time, the COP in Bali in December 2007 adopted the method of avoided deforestation an acceptable method of generating carbon offsets.

The existence of a potential physical volume of carbon offsets does not necessarily imply that this full amount can also be considered a realistic monetary asset. As shown in Figure 12.1, various barriers stand in between the potential physical amount of carbon reduction and the actual marketable amount. First off is the physical amount, which is the total amount of carbon that can be stored in an area if all conditions are optimal. The technical potential follows from knowledge limitations and logging activities.

Institutional barriers are also present in Montserrat. For example, many institutions have some authority in fields relevant to the carbon market. This makes implementing a project more difficult and may prevent foreign carbon investors to step in. Socio-economic barriers also seem present. Land tenure and thus ownership of carbon offsets can form another large barrier, when it is not defined who monitors the region. A general economic concern is whether international carbon markets will indeed emerge as they are expected to do.

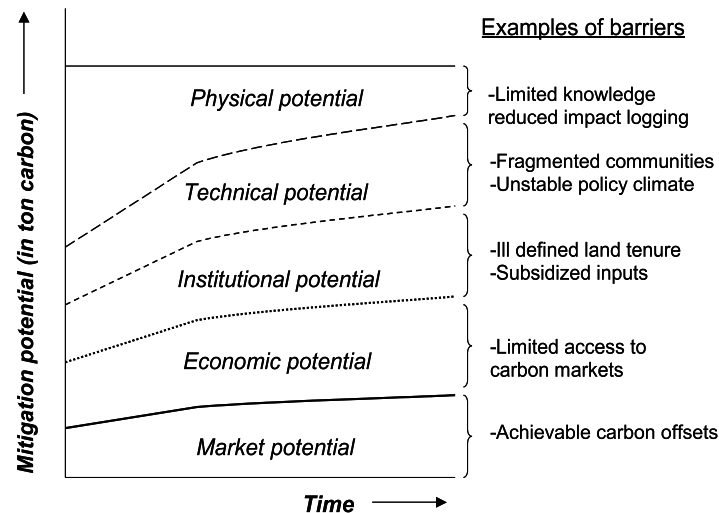


Figure 12.1 Various categories of forestry mitigation options. Source: Sathaye (2001)

Several technical issues must be resolved in order to claim carbon benefits and offsets, and take a place in the international effort to control climate change. The most significant constraint of market development today is that of high transaction costs. Landell-Mills & Porras (2002) distinguish five major categories of transaction costs:

- Project identification
- Project design and implementation
- Project monitoring, enforcement and risk management
- Host country and national project review
- Marketing

Another categorization of transaction costs associated with CDM projects can be found in Michaelowa and Jotzo (2005). Both categorizations are in essence the same, although the latter provides a more detailed discussion on the transaction costs. In this section we will discuss the costs for a carbon sequestration project that are relevant for this study, based on literature, wherein especially comparisons with other projects are important. The costs include project design and implementation costs and project monitoring and verification costs. They probably represent the largest part of the total costs.

### 12.3 Methodologies and results

To value carbon sequestration, the following procedure is used. First, the amount of carbon stored in the Centre Hills forest can be calculated using carbon storage factors in the international literature (e.g. Butcher et al, 1998; IPCC 2000). Second, the monetary value of this amount of stored carbon can be observed in existing markets for carbon credits (e.g. the EU emissions trading scheme) or by using economic valuation studies measuring the actual damage caused by climate change. Although the small size of the Centre Hills forest and the complexity and cost of assessing, monitoring, and crediting carbon storage means that it is not feasible to actually sell carbon credits, this estimate will give some indication of the value of Centre Hills as a carbon sink. Third, after determining the overall value of carbon storage, monitoring and transaction costs need to be deducted.



All forests store carbon so that, if cleared for timber or agriculture, there will be a release of CO<sub>2</sub>, which will contribute to anthropogenic climate change. As presented in Table 12.1, each type of conversion generates a different amount of carbon release.

*Table 12.1 Changes in carbon with land-use conversion (tC/ha)*

Converted from:	Into:	Carbon release
Closed primary forests	Shifting agriculture	204
Closed primary forests	Pasture	220
Closed secondary forests	Shifting agriculture	106
Closed secondary forests	Pasture	122
Open forest	Shifting agriculture	36
Open forest	Pasture	52

Source: Brown, et al. (1993), p.23.

The next step is to determine the different forms of forest conversion taking place in the Centre Hills. As shown in Table 12.2, the current distribution of land cover consists predominantly of medium and large trees taller than five meters.

*Table 12.2 Current distribution of land cover*

Vegetation type	Location	Distribution	Size (in ha)
Wet forest	High elevations with high rainfall	34%	381
Mesic forest	Mid elevations with medium rainfall	56%	635
Dry forest	Low elevations with low rainfall	9%	102
Elfin woodland	Shrubby vegetation at high elevations	1%	8
			1,130

Source: Young (2008)

In order to calculate the carbon value, a certain pattern of conversion needs to be assumed. Because threats are limited in Centre Hills, the land use conversions can also be considered to be small. However, for the sake of demonstrating the carbon value of avoided deforestation, we assume that on an annual basis 0.25% of the primary forest (i.e. 2.8 ha) is converted by invasive species such as wild pigs to degraded land with similar carbon storage values as pasture land. Combining this conversion pattern with the standard carbon release values reported in Table 12.1, (avoided) carbon releases for the deforestation scenario is estimated at 621 tonne of Carbon per year.

Finally, the value of one tonne of carbon needs to be determined. Because it is believed to be economically more efficient to invest in the conservation of carbon sinks in developing countries than to avoid greenhouse gas emissions in developed countries, the international community is willing to pay to prevent such releases resulting from the conversion of rainforest. At present, an international market for trade in avoided carbon emissions is quickly emerging. However, rather than using these market values, we use values from existing valuation studies because these provide a better representation.

Table 12.3 illustrates the large range of the available estimates of marginal costs of climate change. The magnitude of the estimates varies widely. The main parameters determining these variations are the level of the benchmark estimates of climate change, the time horizon and discount rate selected and the vulnerability to climate change over time. The impacts are calculated until the year 2100. Estimates of the marginal damage

costs range between approximately US\$ 6.3 and US\$ 228 per tonne of carbon. In this study, the most recent estimates from the FUND model are adopted at US\$25 per tonne of carbon (Tol 1999).<sup>7</sup>

Table 12.3 The marginal costs of CO<sub>2</sub> emissions (current (1990) value €<sup>1990</sup> / tC) <sup>a</sup>

Time of Emission	Type <sup>b</sup>	1991-2000	2001-2010	2011-2020	2021-2030
Nordhaus (1994)	CBA	12.4	18.6	27.4	n.a.
Cline (1992, 1993)	CBA	6.0-128	7.9-159	10.1-192	12.2-228
Tol (1999)	MC	11	13	15	19
Fankhauser (1995)	MC	21.3	23.6	26.1	28.7
Maddison (1994)	MC	6.3	8.7	11.9	15.7

<sup>a</sup> Exchange rate 1.0332\$=1 €, net present values are discounted to the period of emission.

<sup>b</sup> MC = marginal cost study, i.e. estimate is based on slight perturbation of a baseline.

CBA = cost-benefit study, i.e. estimate is based on a shadow value.

Sources: Reported in van Beukering, 2001, p.68.

An important component of any carbon fund related activity is carbon monitoring and verification (M&V); that is, quantifying and publicly sharing evidence that the project indeed is resulting in real emissions reductions and/or net carbon stored. A sound M&V program is the only way for a project to make claims of carbon offsets and the carbon benefits from which they are derived.

Several dozen carbon offset projects have already been developed throughout the world. The costs of these early carbon offset projects in the forestry sector have been estimated at between US\$ 0.50 and US\$ 2.00 per ton of CO<sub>2</sub> (Dixon *et al.*, 1993). Some of these estimates, however, are “soft” as most participating investors have leveraged support from other organizations, such as environmental and development advocacy groups, whose inputs are generally not accounted for in total greenhouse gas costs.

The final calculation of the carbon value of avoided deforestation of the Centre Hills is simple, taking the 621 tons of carbon at an economic value of US\$25 minus the M&V costs of US\$2, bringing the total value at US\$14,295 which is equivalent to EC\$38,454. Note, however, that this is the economic value and not the financial revenue that can possibly be retrieved from the carbon market. This latter value is substantially lower, since the market price for forests such as Centre Hills is between US\$2 and US\$4 per tonne of carbon, hardly making up for the M&V costs.

<sup>7</sup> For reasons of comparison, a present value of the carbon reduction potential is determined on the basis of several carbon-offset projects and initiatives that have implemented around the world. Ecosecurities (2002) shows how prices of a ton of carbon range from US\$0.5 to US\$9 for Kyoto complaint project and from US\$0.5 to US\$2 for non-Kyoto compliant project.



## 13. TEV and scenarios

### 13.1 Introduction

The main aggregate indicator used in this study is the Total Economic Value (TEV). As explained in Chapter 3, the TEV represents the sum of all marketed and non-marketed benefits associated with an ecosystem or environmental resource. This Chapter estimates the TEV, presents various projections representing potential future scenarios for economic value of the Centre Hills, and conducts a sensitivity analysis for the most influential parameters underlying the TEV.

### 13.2 Total Economic Value

In the preceding chapters, all individual ecosystem services provided by the Centre Hills were estimated. These estimated monetary values for the various ecosystem services are determined for the present year. Clearly, two benefit categories dominate over the other benefits. Due to the importance of a natural environment and wildlife for visitors to Montserrat, the tourist value of the Centre Hills makes out 32% of the TEV. In addition, being the sole source of drinking water on the island, water supply represents 30% of the TEV. Other important values are forest products and species conservation. Carbon sequestration, which is a value category that often dominates in the larger nature reserves around the world, is almost negligible in the TEV for Centre Hills due to the lack of avoided deforestation potential.

*Table 13.1 Overview of annual benefits*

Category	Value (EC\$)	Value (US\$)	Share
Tourism & research	1,206,503	450,188	32%
Water supply	1,134,000	423,134	30%
Species conservation	498,338	185,947	13%
Forest products	422,497	157,648	11%
Recreation	211,658	78,977	6%
Aesthetic quality	187,144	69,830	5%
Hazard protection	90,909	33,921	2%
Carbon sequestration	38,454	14,349	1%
<i>Total Benefits</i>	<i>3,789,503</i>	<i>1,413,994</i>	<i>100%</i>

### 13.3 TEV over time

Although economic value of the ecosystem services were determined for its current value, the Centre Hills delivers a stream of services that are received continuously over time. In order to calculate not only the value in the present year but also the total value of ecosystem services over time, we need to make a projection of what the value of these services will be over time. We could of course assume that the value of services remains constant over time but this may be unrealistic if key drivers of value are likely to change.

For example, the population of Montserrat is expected to increase over the coming years if the volcano remains stable. With more people utilising the ecosystem services, the value of the Centre Hills will increase. A projection of future values will therefore be made based on projections for key drivers of value, including population, tourist visitor numbers, water use etc. The relevant Montserrat government departments have been consulted for advice on what projections should be used.

The Sustainable Development Plan for Montserrat reports a number of 10,000 residents as the preferred population of the island. Such a population is sufficient to keep a viable economy without putting too much pressure on the islands resources. The main question remains on if and how this population size will emerge. Acknowledging the uncertainties and unpredictability of the population size, three scenarios have been developed representing lower bound, upper bound and average projections (see Figure 13.1). These scenarios form the basis for further calculations of the TEV.

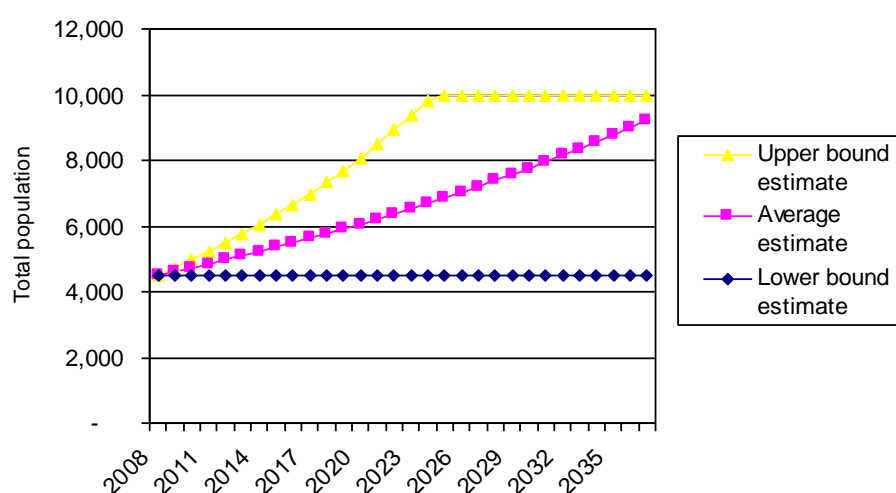


Figure 13.1 Scenarios for population growth

Besides the uncertainties concerning the underlying parameters such as population growth, uncertainties also relate to the actual monetary estimates themselves. As presented in the previous Chapter, minimum and maximum estimates have been determined for each individual ecosystem service. These are presented in Table 13.2. The range in the value estimate varies by type of ecosystem service, but on average deviates approximately 50% around the average.

Table 13.2 Value ranges for the individual ecosystem services (in US\$)

Category	Minimum value	Average value	Maximum value
Water supply	211,567	450,188	671,642
Tourism & research	314,922	157,648	581,187
Forest products	68,586	423,134	246,710
Species conservation	144,543	185,947	227,351
Aesthetic quality	30,419	69,830	109,242
Recreation	62,953	78,977	95,001
Hazard protection	16,961	14,349	50,882
Carbon sequestration	7,174	33,921	28,697
<i>Total Benefits</i>	<i>857,125</i>	<i>1,413,994</i>	<i>2,010,711</i>

Assuming that with a growing population, more people will enjoy the amenities of the Centre Hills, the economic value of a number of ecosystem services are considered to increase proportional with the population of Montserrat. Note that not all value categories depend on the population size. The economic value of tourism and research, hazard protection and carbon sequestration are independent from the population size. On the basis of this assumption, as is shown in Figure 13.2, different scenarios for annual benefits over time can be determined:

- Lower bound estimate: Combining the lower bound projections for the population growth with the minimum value estimates generates the lower bound estimate of the annual benefits.
- Upper bound estimate: Combining the maximum population trajectory with the maximum value estimates generates the upper bound value over time.
- Average estimate: The average projections for population growth are combined with the average values, leading to the average scenario of the economic value of the Centre Hills.

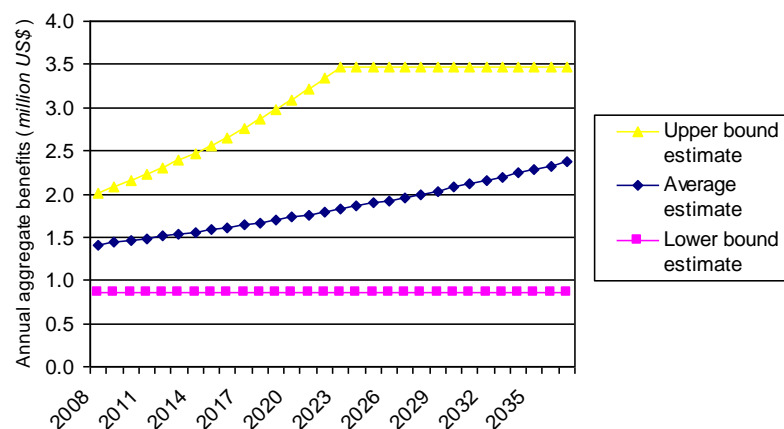


Figure 13.2 Annual benefits over time (2008-2037)

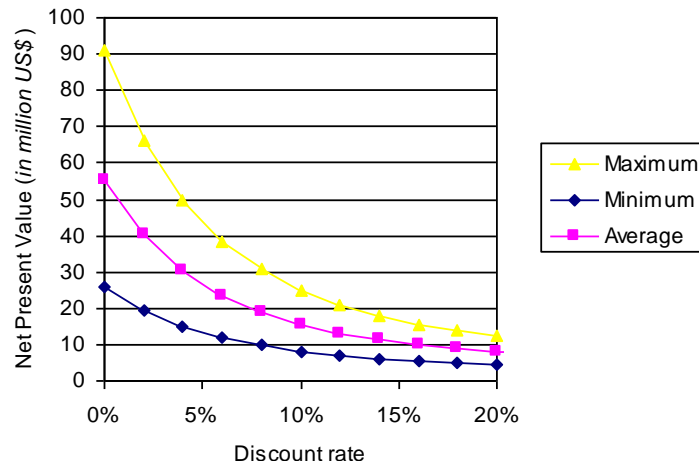
One way to judge whether the absolute TEV of Centre Hills is high or low is to compare the value on a per hectare basis to economic valuation studies of other forest reserves. An overview of values of forests by Pearce and Moran revealed an economic value of tropical forests between US\$200-500 per hectare. Constanze et al. 1997 estimate the NPV of tropical forest at US\$2,000 per hectare.<sup>8</sup> The estimates for the Centre Hills range from US\$782 to US\$1,834 per hectare per year, and thus fall in the same range of the TEV estimates reported in the literature.

Another way of judging the TEV of the Centre Hills is whether its societal value justifies the current and future management costs of the nature reserve. Depending on the rigour of future management, the costs of management range between US\$ 0.5 million and US\$1.5 million per year (pers. comm., S. Sanders, May 2008).

<sup>8</sup> There is also an elaborate collection of specific case studies on valuation of forests. For example, the TEV of pristine tropical forest in Cameroon was estimated at US\$3,432 per hectare (Ruitenbeek, 1988). Another example is the TEV of the Leuser National Park in Indonesia which was determined at a value of US\$9,920 per hectare (van Beukering et al. 2003). However, given the specific characteristics of the sites do not justify a comparison with the estimate of Centre Hills.

### Sensitivity analysis

Figure 13.3 shows the sensitivity of the TEV to the discount rate. By definition, the TEV declines with higher discount rates due to the fact that future benefits are discounted more than without discounting. Assuming a discount rate of 4% for a 30-year period, the TEV is estimated at US\$30 million, with a minimum and maximum of US\$15 million and US\$50 million, respectively.



*Figure 13.3 Sensitivity analysis of the discount rate on the NPV of the baseline scenario of the Centre Hills (period 2008-2037)*

## 14. Case study on the control of invasive species

### 14.1 Introduction

Globally, the United Nations Environment Programme (UNEP) has estimated that invasive species represent a major factor in the potential extinction of 30% of threatened bird species, and 15% of threatened plant species. Overall, approximately two-thirds of species extinctions may involve competition with invasive species. More alarmingly, invasive species are considered to be THE greatest threat to biodiversity in geographically and evolutionarily isolated systems such as islands of the Caribbean (Kairo et al., 2003).

Thus, similar to other islands in the Caribbean region and elsewhere around the world, invasive alien species pose perhaps the most severe threat to Montserrat's native biodiversity. Black (ship) rats (*Rattus rattus*), brown rats (*Rattus Norvegicus*) and feral pigs (*Sus scrofa*) are the most problematic (Young ed., 2008).

A wide range of flora and fauna species are likely to be affected by these invasive species, which may have resulted in population declines and extinctions of these species, and others that rely on them, and will do in the future. Most worryingly, three Critically Endangered species, the oriole, galliwasps and mountain chicken are vulnerable to the effects of introduced rats and feral pigs. The impact of invasive species may be sufficiently strong and wide-ranging to influence the overall functioning of the Centre Hills ecosystem (Young ed., 2008).

Urgent attention is therefore required for the catastrophic threats of invasive rats and pigs to the Centre Hills and eradication and/or control programmes are a priority conservation action. In this chapter, we perform a cost-benefit analysis (CBA) of such programmes. CBA is the most commonly used decision support tool for assessing and comparing economic and financial trade-offs (Van Beukering, 2007). The CBA is applied here as an illustrative case study for the use of valuation information generated by this research.

For each invasive species, a literature review is given first in order to provide insight into experiences from other areas that have been dealing with the problem. Next, the problems on Montserrat are described, including the impact of these species on the Centre Hills. This is followed by a description and estimation of the costs of suggested eradication/control techniques on Montserrat. In the third section, these estimations, together with the valuation information generated by the choice experiment (chapter 4-7), are then combined in a CBA. Finally, a sensitivity analysis is performed to test how vulnerable results are to changes in values and assumptions. The chapter ends with a discussion of the CBA results.

### 14.2 Feral pigs

#### Literature

There are various studies that provide examples of the impact of feral pigs on (island) ecosystems. In some island forests pigs have had catastrophic impacts, effectively



destroying forests by preventing regeneration. In other islands, they have less massive, but still important impacts as predators and herbivores (Young ed., 2008).

Kessler (2001) indicates that feral ungulates (feral goats and pigs) were changing Sarigan island (commonwealth of the Northern Mariana Islands) from a tropical forest to a grassland habitat. An eradication programme removed the feral ungulates by helicopter shooting, ground shooting, trapping and tracking by dogs. Vegetation monitoring showed that species richness and tree seedlings increased afterwards and the native forest is expanding and regenerating again.

Schuyler et al. (2001) discuss pig removal efforts that have been taking place since 1990 on Santa Catalina Island (California Channel Islands). To date, 11,855 pigs have been killed and monitoring indicated an increase in vegetation cover and species diversity from 1990 to 2000. In addition to the removal methods used on Sarigan Island, night spotlighting was applied during the eradication efforts on Santa Catalina.

Also on the Hawaiian Islands, feral pigs are considered pests with negative impacts on native biota. Due to these detrimental effects several management plans were devised that attempted to control the ecological damage caused by pigs. This included an extensive fence network and an intensive hunting programme to reduce, but not eradicate, the feral pig population from the Hawai'i Volcanoes National Park (Nogueira et al., 2007). The problem still continues here and Nogueira et al. (2007) therefore suggest incorporating behavioural approaches to develop more effective control techniques.

The largest pig removal to date is reported from Santiago Island in the Galápagos Archipelago, Ecuador. Pigs have had a variety of adverse impacts on the native biodiversity of Santiago Island and are thought to have played a substantial role in the majority of extinctions on the Galápagos Islands. Over 18,000 pigs were removed during this 30-year eradication campaign, using a combination of ground hunting and poisoning, access to animals by cutting more trails and an intensive monitoring program (Cruz et al., 2005).

### The problem on Montserrat

Feral pigs (*Sus scrofa*) are thought to be a relatively new problem on Montserrat, having appeared in the Centre Hills since 2000, following the escape of domestic stock from abandoned agricultural areas in the south of the island. They spread through much of the Centre Hills with astonishing speed until a major control effort in 2003-4 pushed them back to the south-eastern edges of the hills (Young ed., 2008). The project took place over three months and reduced the number of pigs from approximately 1,500 to 1,000. Costs of the project were US\$ 18,657 (EC\$ 50,000), but funding was limited to further continue the eradication efforts (pers. comm. J. (Scriber) Daly, December 2007; L. Martin, February 2008). Since the relaxation of control, populations are recovering and the current number of feral pigs is estimated around 2000 (pers. comm. J. (Scriber) Daly, December 2007).

Chapter 9 reports that around 15 persons are currently hunting feral pigs in the Centre Hills, either by using guns or dogs. The estimated numbers of pigs being killed vary between approximately 30 and 100 pigs a month, generating income from the sale of meat. These numbers are not sufficient to control the pig population and prevent them

from causing serious damage to the forest, mostly because of their fast breeding rate. These problems are further emphasized by James (*Scriber*) Daly (December 2007) stating: “there is more destruction than that there is money coming out of it.”

The exact impact of pigs on the Centre Hills is unclear, but current observations and experiences from other islands (see previous section) indicate that the problems might be severe. Pigs are uprooting and destroying forest grounds, which can lead to forest degradation by preventing regeneration. In addition, uprooted areas are prone to erosion and landslides, which might impact streams and marine ecosystems, causing damage to aquatic life ((pers. comm. J. (*Scriber*) Daly, December 2007). Uprooting activities are also depleting stands of the national flower *Heliconia* that may have a negative impact on the oriole population (chapter 9). Direct impacts also exist, because feral pigs are likely to be effective predators of ground-nesting birds and larger terrestrial herptiles, such as mountain chicken and galliwasp. Whether feral pigs become significant ecosystem engineers, changing habitat structure and even, ultimately, destroying the forest remains to be seen (Young ed., 2008).

### Pig eradication techniques

As mentioned above, several techniques can be used for eradicating and/or controlling pigs. The most important ones being helicopter shooting, fencing, poisoning, trapping and ground hunting (either with guns or dogs). Integrated management using a range of control techniques produces the best results (Choquenot et al., 1996). However, a number of factors determine which combination of techniques is most suitable for a specific area. These factors include for example:

- Area size
- Accessibility of the area
- Population characteristics
- Available funding
- Capacity to carry out the activities

In addition, it is important to consider the goal of such a programme: complete eradication or sustained control of the pig population. The literature suggests that an intense eradication effort is preferred (Cruz et al., 2005; Schuyler et al., 2001; Zavaleta et al., 2001). Control requires indefinite investments of time, tools and money to keep populations under control and prevent further spread. Although eradication can require large short-term investments, successful removal can be achieved within months or years and gives the best chance for native biodiversity to recover (Zavaleta et al., 2001). Therefore, it is suggested that complete eradication of feral pigs should be the main goal of such a programme on Montserrat.

With respect to choosing the most suitable techniques for Montserrat, helicopter shooting will not be effective since the area is largely forested. The type of terrain is also one of the reasons that fencing is unlikely to be applied in the Centre Hills. In addition, possibilities for fencing have already been investigated on Montserrat and were considered to be too expensive. It would also involve issues related to land access, since approximately 64% of the area is privately owned (pers. comm. S. Mendes, February 2008). Arguments against fencing are further enhanced by Choquenot et al. (1996) who state that fences are of limited value because no design keeps feral pigs out indefinitely.

Poisoning is considered to be one of the most cost-effective methods, but also includes negative aspects as legality and effects on non-target species (Cruz et al., 2005; Schuyler et al., 2001). Also trapping can have negative effects on non-target species and people visiting the area. This method is therefore not preferred on Montserrat either (pers. comm. S. Mendes, February 2008). Trapping is, however, a successful and efficient method in removing large numbers of pigs where poisoning is impractical (Choquenot et al., 1996; Schuyler et al., 2001).

Ground hunting with guns and dogs seems to be the most suitable technique on Montserrat. These methods are widely used and generally speaking effective at all pig densities (Schuyler et al., 2001; Choquenot et al., 1996; Cruz et al., 2005; Kessler, 2001). However, problems arise since pigs become wary of the hunters (especially dogs) as soon as they relate them to danger. As a result, escaped pigs go into hiding and are difficult to catch afterwards (pers. comm. G. Hilton, October 2006; J. (Scriber) Daly, December 2007).

Table 14.1 provides an overview of these techniques and their suitability on Montserrat. Four criteria are selected: effectiveness, costs, accessibility of the Centre Hills and side-effects on non-target species. The techniques are evaluated by assigning scores to each of the criteria. As can be seen from the table, ground hunting receives the highest score, being the most suitable eradication technique on Montserrat.

*Table 14.1 Pig eradication techniques and their suitability on Montserrat*

Technique	Criteria (scores: – negative; 0 neutral; + positive)				
	Effectiveness	Costs	Accessibility	Side-effects non-target species	Score
Helicopter shooting	+	-	-	0	-1
Fencing	0	-	-	0	-2
Poisoning	+	+	+	-	+2
Trapping	+	+	+	-	+2
Ground hunting	+	+	+	0	+3

## Costs

In October 2006, the Centre Hills Project made an effort to apply for a US\$50,000 project funded by OTEP for the eradication of pigs on the island. Overseas experts were consulted to make an estimation of the costs of such a programme (amongst which J. Parkes – Landcare Research, New Zealand and G. Hilton – RSPB (Royal Society for the Protection of Birds), UK). Estimated costs resulted at US\$157,742 (EC\$ 424,325) which exceeded the available funding from OTEP. This estimation will be used as a basis for this cost-benefit analysis.

Following the advice in 2006 and in accordance with the above, ground hunting is the main technique suggested for an eradication programme on Montserrat. The team ground hunting should be followed by so-called ‘Judas pigs’. These are radio-collared sterile local pigs that join up with, and are used to locate, groups that are difficult to find by other methods. The located animals can then be shot or killed by dogs. The technique is usually applied to low density populations or for survivors of other control campaigns that have become particularly wary (Choquenot et al., 1996). To catch these pigs, the

setting of pen traps is recommended. The estimation in 2006 was based on a programme of approximately six months with three teams existing of one shooter and two dog hunters. An estimation of the costs of this programme is included in Appendix VI. Adding 5% due to inflation, total costs sum up to US\$ 166,247 (EC\$ 445,541) (pers. comm. S. Mendes, February 2008).

### 14.3 Invasive rats

#### Literature

The negative effects of introduced species of rats (*Rattus rattus*, *R. norvegicus* and *R. exulans*) on indigenous island animal and plants have been long recognised and are well-documented (Young ed., 2008). Towns et al. (2006) present a review of global literature on the effects of rats on island flora and fauna. This review is summarised by Young ed. (2008) in the following paragraphs.

The effects of rats can either be direct, e.g. through predation or exploitation competition for food, or indirect, e.g. through changing habitat structure leading to shifts in predator-prey dynamics or access to food resources. There is increasing evidence that the impacts of rats are sufficiently pervasive to affect ecosystem structure and function and have far-reaching consequences for the persistence of island biotas. Recent studies also suggest that the effects of introduced rats on islands have probably been greatly under-estimated. Effects can be over relatively short time-scales, e.g. effects of high predation rates by rats on small lizards, or over much longer periods, e.g. low recruitment due to seedling predation by rats preventing forest regeneration.

Globally, black rats *R. rattus* have been associated with the declines or extinctions of the largest number of indigenous vertebrate species, around 60 species, and are considered the most damaging of the introduced rats. They are arboreal and can predate birds' nests, tree-living reptiles, fruit and seeds and are also capable swimmers so therefore are good colonisers of islands. Brown rats *R. norvegicus* are also known to have major negative impacts on indigenous island species, albeit less wide-ranging, but due to their greater body size may affect larger prey species such as seabirds.

#### The problem on Montserrat

Both black (ship) rats (*Rattus rattus*) and brown (Norway) rats (*Rattus Norvegicus*) have been introduced onto Montserrat, probably with the arrival of the first Europeans roughly 400-500 years ago, and are now abundant throughout the Centre Hills forest. Black and brown rats are highly likely to be posing a serious threat to the persistence of a large number of the Centre Hills taxa, which may be sufficiently strong and wide-ranging to influence the overall functioning of the Centre Hills ecosystem. Most worryingly, three Critically Endangered species, the oriole, galliwasp and mountain chicken possess traits that have been shown elsewhere to pre-dispose them to being vulnerable to the effects of introduced rats (Young ed., 2008).

Young ed. (2008) present ten taxonomic groups that have demonstrated global vulnerability to black and/or brown rats (based on Towns et al., 2006) and indicate the wide range of plants and invertebrates in the Centre Hills that are likely to be affected by rat predation:

Amongst the reptiles and amphibians, the galliwasps and mountain chickens would appear to be most vulnerable as they are large-bodied and nocturnal and probably have slow annual reproductive rates. Further, mountain chickens lay eggs in rookeries, which can be easily raided by rats. Mountain chickens in the Centre Hills have been found with wounds that are consistent with rat bites, although no evidence exists that rats are impacting on their population. Other reptile species such as the racer, blind snake, anole and turnip-tailed gecko could also be susceptible to the effects of introduced rats.

No small terrestrial or ground nesting birds currently occur on Montserrat but a number of passerine species may be vulnerable to the arboreal black rat, including the Montserrat oriole, as well as forest thrush, and others. Black rats have been observed to predate the eggs and chicks of the Montserrat oriole. In some years rats achieve very high densities in the Centre Hills resulting in high predation rates and a concomitant decrease in oriole annual productivity, leading to longer term population effects.

Terrestrial flightless invertebrates, especially large, nocturnal and ground-dwelling species, are particularly at risk from rat predation as well.

Rats are also known to have a major impact on plants, through seed, fruit and seedling predation and affect recruitment in plant populations. Plants with fleshy fruits and/or large edible seeds, or heavily scented inflorescences are particularly vulnerable. In addition, Young *et al.* (2008) provides evidence that the number of exotic fruiting trees in the Centre Hills forest is positively related to the abundance of rats in an area. Higher numbers of rats supported by plentiful food non-native fruit resources will result in high predation pressure on indigenous plants and animals, which may be sustained even when native prey decline.

Research is currently taking place to determine the nature and magnitude of rat impacts and to evaluate the costs, impacts and feasibility of ongoing rat control in the Centre Hills. As a result of these research activities, more information on the quantified effects of rats on the Centre Hills and its biodiversity will be published soon (Hilton, 2007).

### **Rat control techniques**

Recent work on islands in New Zealand, Australia, Hawaii and elsewhere shows that rat numbers can be controlled in island forests, where (as on Montserrat) complete eradication is not feasible (Hilton, 2007). Most control measures use a combination of poisoning and snap trapping. Details on the methods used for rat control and/or eradication are not discussed in this section, because the suggestions for rat control can be based on experiences from the current rat experiment on Montserrat.

The rat experiment is designed with one 13-hectare experimental area in which rats are controlled over the medium-term, and two control areas. At all three sites, the abundance of plant seedlings, insects, amphibians, reptiles, and bird nesting success, before and after reducing the rat numbers in the experimental area are measured. The experiment involves several methods. The initial phase included a reduction in rat numbers by setting out poison bait in bait stations. After this knockdown, the longer-term ongoing rat control commenced with the use of snap-traps. All traps are placed inside weld-mesh tunnels that discourage non-target wildlife from approaching the peanut butter bait. Throughout the experiment, rat numbers are monitored using tracking tunnels. The

proportions of tunnels in which rat footprints are found are used as an index of rat abundance (Hilton, 2007).

### Costs

Based on (preliminary) results from this experiment, G. Hilton (pers. comm. March 2008) provided an indication of the costs of ongoing rat control in the Centre Hills. A total of US\$ 223 per hectare per year is suggested. The breakdown of this cost estimate is presented in Table 14.2.

*Table 14.2 Costs rat control*

Item	Cost (US\$/ha/year)	Based on
Poison bait	16.80	2.8 kg bait per hectare per year; US\$ 6 per kg; assuming 8 months poisoning per year
Bait stations	9.32	Replace every 5 years; use 4 stations per ha; cost 28.9 GBP for 5
Tracking tunnels	4.79	Replace tunnel every 2 years; use 2 per ha; cost includes tunnel, foam, food-coloring, papers
Peanut butter baits	2.40	4 traps per ha; run traps for 4 months per year; with 3 trap-night sessions every 3 weeks within that period
Snap-traps	4.11	4 traps per ha; US\$ 5.14 each; replace every 5 years
Weldmesh tunnels	2.80	Replace every 5 years; use 4 traps per ha; US\$ 3.50 per tunnel
Labour	182.78	26 person-hours per ha per year; US\$ 7.03 per hour
<i>Total</i>	<i>223.00</i>	

These costs are relatively high, compared to for example a New Zealand study that estimate costs over 25 years of conventional rat control as being between US\$ 30-100 per hectare per year (Clapperton & Day, 2001). This is explained by the fact that the great majority of the costs is down to labour costs and reflects that:

- The terrain of the Centre Hills is so difficult that one cannot service many bait stations/traps/tracking tunnels per hour in Montserrat's Centre Hills.
- All work is done in a 2-person team. This could be done by a single fieldworker in relatively little extra time, but this is not done in Montserrat (pers. comm. G. Hilton, March 2008).

It is assumed that rat control, if it is to be used as a conservation measure in the Centre Hills, should be zoned into particular areas of high conservation value. The high priority areas might be chosen on a variety of criteria. For example areas with high densities of several high priority, rat-sensitive species or areas where rat numbers are already low so that rats are easier to control. It could also be the other way: hit the rats where they are most abundant and therefore problematic. Another criterion could be to choose areas with easy access that would make the programme more cost effective. Such zones are not determined yet and the rat experiment is designed to provide information about how useful a rat control zone might be (pers. comm. G. Hilton, March 2008).

This means that we can only estimate the costs of rat control in hypothetical areas of conservation here. G. Hilton (pers. comm. March 2008) suggests a surface area of conservation zones for rat control between 50 and 250 hectares. Calculating the total costs of rat control, by using the average number of hectares (150) and the estimated US\$223 per hectare, generates a total cost of rat control of US\$ 33,450 per year.

#### **14.4 Cost-benefit analysis**

Based on this information and the values generated by the choice experiment (Chapter 4-7), the monetary benefits and costs of eradicating/controlling invasive species can be compared in a CBA.

##### **Benefits**

The benefits consist of two quantified components. The first benefit results from the income generated by selling the pig meat after eradication. Assuming that meat from 50% of the 2000 pigs (the estimated total number at present) will actually be sold, leads to a onetime benefit of US\$ 144,590 (EC\$ 387,500) (applying an average weight of 77.5 pounds per pig and EC\$ 5 per pound).

In addition to this onetime benefit, an annual stream of benefits is generated by the local WTP for control of invasive species. This value resulted from the choice experiment and is shown to be a highly desirable policy with respondents willing to pay a total annual amount of US\$ 121,295 (almost US\$ 60 per household). As discussed in chapter 4, this value is relatively high because people probably associate the problem of invasive species with a number of aspects (for example degradation of the forest and species abundance, and also negative impacts on water quality, basic dislike of invasive species etc.).

A third important indirect benefit stream of the eradication and control of invasive species results from “the damage avoided” to biodiversity. Literature and current experiences indicate that pigs and rats cause significant short and long-term damages to biodiversity, and likely to the Centre Hills ecosystem as a whole. It is however outside the scope of this research to quantify these effects and to express them in monetary terms. Due to limited available information, it was decided that these indirect benefits could not be estimated on the basis of valid assumptions. The “damage avoided” should therefore be considered as an important missing factor in the CBA, which has to be recognized in the results of the analysis.

##### **Costs**

The costs of the programmes consist of three components. Two of the components are related to pig eradication: the onetime cost of eradication (US\$ 166,247) and an annual stream of costs resulting from lost hunting revenues once all pigs have been eradicated. The latter can be derived from the estimated number of pigs killed (30 to 100 pigs a month) and generates an average annual income from pig hunting of US\$ 127,528 (EC\$ 341,775). The third component involves the annual stream of costs of rat control that is estimated at US\$ 33,450.

### Net Present Value

The next step in order to derive the net present value (NPV) is to calculate the present value (PV) of both costs and benefits. In this case, a discount rate of 4% is applied over a 30-year time scale. Present values are then summed across years to obtain the total present value benefits and costs. These resulted in US\$ 2,363,317 and US\$ 3,110,861 respectively. Subtracting the present value costs from present value benefits gives a negative NPV of US\$ 2,003,418.

Representing these results by the benefit cost ratio (BCR) shows the relative magnitude of benefits and costs. The BCR is 0.76, indicating that the costs are about 1.3 times the benefits. This implies that eradicating pigs, together with the control of rats should not be considered worthwhile due to high costs of both programmes. An overview of the CBA results is presented in Table 14.3.

*Table 14.3 Results CBA invasive species*

Benefits	Value (US\$)	Time scale	Costs	Value (US\$)	Time scale
WTP invasive species	121,295	Annual	Rat control	33,450	Annual
Income pig meat after eradication	144,590	One time	Lost income from pig hunting	127,528	Annual
			Pig eradication	166,247	One time
Damage avoided to biodiversity	Unknown		Damage avoided to biodiversity	Unknown	
<i>PV benefits</i>	<i>2,363,317</i>		<i>PV costs</i>	<i>3,110,861</i>	
<b>Combined NPV =</b>	<b>- 747,544</b>				
<b>Combined BCR =</b>	<b>0,76</b>				

### Sensitivity analysis

Since the monetary values of the costs and benefits are not known with absolute certainty, we tested how sensitive the CBA results are to changes in values and assumptions. The sensitivity analysis shows that the annual streams of relatively high costs of lost income from pig hunting and the benefits resulting from the WTP for control of invasive species drive the results. The results are most sensitive to changes in the costs of lost income from hunting. Changes in other values did not change the NPV more than proportionally (i.e. for example changing a value by 5% resulted in a change of the NPV by less than 5%). The results are least sensitive to the income from pig meat after eradication and the onetime cost of eradication. The reason for this is the relatively low contribution to the total values compared to the other benefits and costs.

The results are not sensitive to changes in the discount rate, since the trade off is the same for every time period (except for the first year). This would only be the case if streams of benefits and costs change over time and/or benefits and costs occur in different time frames.

Because the costs are exceeding the benefits, we tested how sensitive the results are to changes in total costs and to the major costs of each of the programmes separately. The



sensitivity analysis of the total costs shows that a cost reduction of approximately 25% (a cost sensitivity of 75%) is necessary in order to reach the break-even-point (i.e. the point where the benefits and costs are equal and/or the BCR=1). The results of this analysis are presented in Figure 14.1.

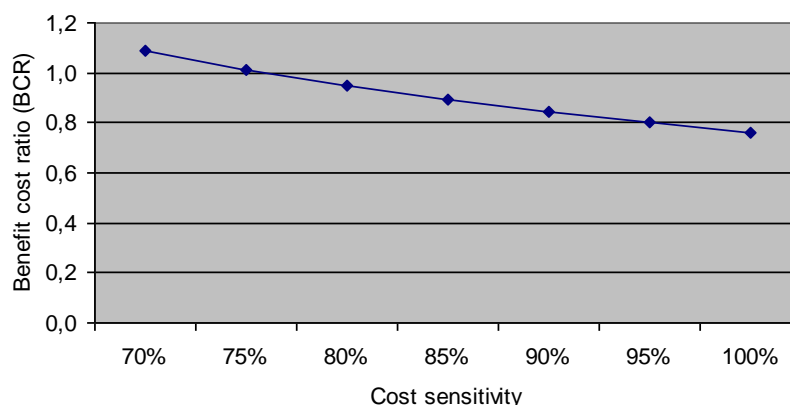


Figure 14.1 Sensitivity analysis of the total costs on the BCR

Performing the same sensitivity analysis for the costs of lost income from pig hunting only (the value that mainly drives the results) shows that these costs should be reduced by approximately 32% (a cost sensitivity of 68%) in order to reach a BCR of 1 (Figure 14.2). It should be noted that the estimated income from pig hunting is based on many assumptions (i.e. numbers of pigs killed, prices of meat, weight of pigs). The value that is included here (US\$ 127,528) is the average value resulting from the maximum value indicated by J. (*Scriber*) Daly and the minimum value indicated by C. (*Blacka*) Fenton (see also chapter 9). These values vary considerably and if we would apply for example the minimum value (US\$ 52,631), the BCR becomes 1.36. This would mean that both programmes (eradication of pigs and control of rats) could be considered worthwhile. Thus, uncertainties in the values included in the cost estimates have important impacts on the CBA results and should therefore be considered with caution.

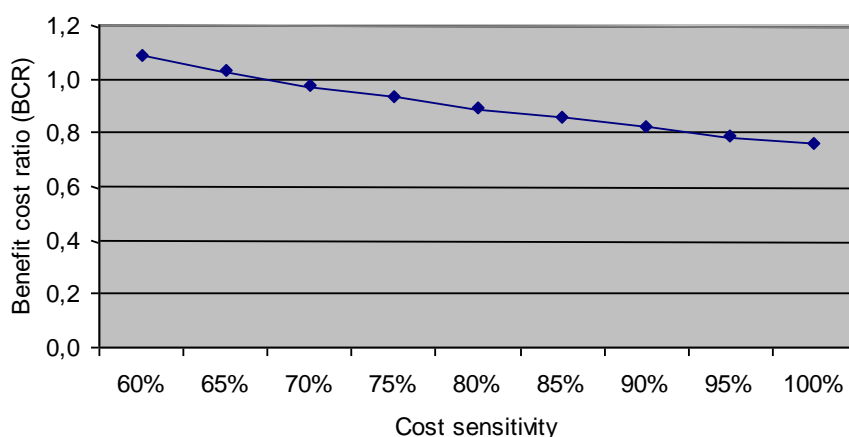


Figure 14.2 Sensitivity analysis of the costs of lost income from pig hunting on the BCR

Since the applied number of hectares rat control is a rough estimate, we also tested for changes in the BCR within the entire suggested range (50-250 hectares) (Figure 14.3).

As can be seen in the figure, the CBA results do not change considerably with changes in the number of hectares of rat control (i.e. BCR does not exceed one).

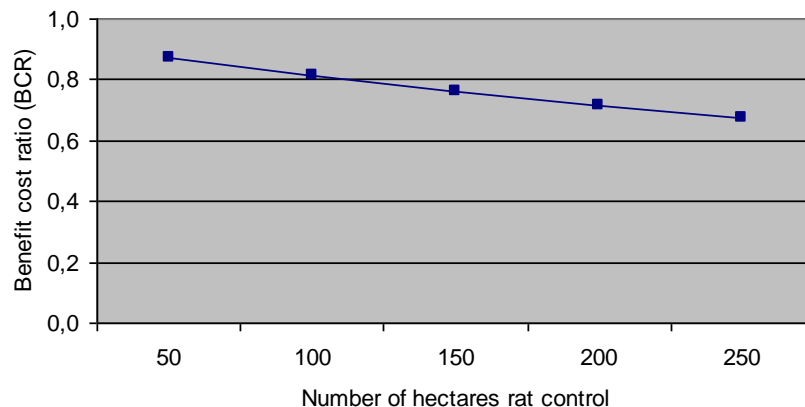


Figure 14.3 Sensitivity analysis of the number of hectares of rat control on the BCR

### 14.5 Discussion CBA

We want to emphasize that this CBA is an illustrative case study for the use of valuation information in public decision-making. The majority of the values presented in this section are not based on scientific data, but required many assumptions and estimates.

In addition, an important stream of benefits – damage avoided to biodiversity – could not be included in the analysis. Available information does however imply that these benefits would make a considerable contribution to the total stream of benefits resulting from eradicating and controlling invasive species. This means that including this damage avoided would likely cause the CBA to confirm viability of such programmes.

It should also be noted that performing separate CBAs for the control of rats and the eradication of pigs would probably provide better insight into the desirability of each programme. This was however not feasible here, because WTP values for the control of invasive species are estimated jointly for the eradication/control of both pigs and rats.

We are not able to estimate WTP values for the eradication/control of pigs and rats separately. The results of this CBA do suggest that considering either pig eradication or rat control might be worthwhile instead of both programmes. Especially the latter seems to provide substantial benefits due to lower costs compared to pig eradication.

We therefore underline that decision makers should not treat the results of this CBA as a finished analysis, but rather as a framework for decision-making using quantitative information. It is highly recommended that further research on the costs and benefits of the control/eradication of invasive species should be conducted in order to revise and refine these findings.

## 15. Conclusions and recommendations

After the destructive impact of the volcanic activity starting in the late 1990's, the Centre Hills now comprises the largest intact forest area remaining on Montserrat, providing a number of important environmental goods and services to the people of Montserrat. This study aimed at increasing our understanding of the economic importance of further conservation of the area.

### 15.1 Main results

Although the study covered a wide range of issues and addressed numerous ecosystem services, four main activities took place as part of the study, generating the following results.

First, a *choice experiment (CE)* was used among the Montserrat population to estimate monetary values for the aesthetic, species conservation, and recreational services provided by the forest. Perhaps surprisingly, the control of invasive species, which was also included in the experiment, was considered the most important attribute. This is possibly because invasive species were perceived as having an impact on a number of economic services provided by the Centre Hills. On average, each household is willing to pay (WTP) US\$58 per year for the control of invasive species. The results of the choice model justify the implementation of a payment mechanism for residents, which could generate earmarked financial support for management of the Centre Hills via the proposed Environmental Fund (i.e. under the new Environmental Management Bill).

Second, the *Total Economic Value (TEV)* was calculated showing the relative importance of the ecosystem services from the Centre Hills forest. The tentative estimate of the TEV is around US\$1.4 million per year, with a minimum and maximum value of US\$0.9 million and US\$2 million per year, respectively. Because the Centre Hills are the only source of drinking water on Montserrat, 30% of the TEV of the Centre Hills is determined by water services. The most important value, however, is the tourism value, which comprises 32% of the TEV of Centre Hills. Species abundance (18%) and forest products for domestic consumption (15%) are also highly valued ecosystem services in Montserrat.

Third, the valuation estimates were used in an extended *cost benefit analysis (CBA)* of an eradication and control programme for invasive pigs and rats in the Centre Hills. The costs include the onetime cost of pig eradication, an annual stream of lost hunting revenues after eradication and an annual stream of costs of rat control. The benefits include the onetime income generated by selling the pig meat after eradication and the annual stream of benefits to residents, which were derived from the choice experiment. However, due to the lack of information, the important value of avoided damage to biodiversity was excluded. Assuming a discount rate of 4% over a 30-year period gives a benefit-cost ratio of 0.76. Because of the exclusion of avoided damage to biodiversity, this outcome does not necessarily imply that the programme is not economically feasible. To generate a more definite conclusion about the economic feasibility, more research is needed.

Fourth, as part of the stakeholder engagement and dissemination process of this study, a *workshop* was held among the main stakeholders that influence the management of the Centre Hills. On the basis of the results of the study, the workshop aimed at identifying policy opportunities to apply the lessons learned in the study in the context of the Centre Hills. The workshop highlighted three crucial ecosystem services in which economic principles and mechanisms could play a more important role: tourism, water and biodiversity. Recommendations for each of these sectors are highlighted below.

For all of these sectors we recommend to develop a data collection protocol for the most essential and fundamental data on a more structural basis. At present, some of these data are collected on a more ad-hoc basis, without an overall data collection plan. We do not recommend an endless process of data collection, but having a minimal basis of data availability is essential in developing funding mechanisms in the three sectors discussed.

## 15.2 Recommendations for tourism

The sector that was shown to benefit the most from a well-conserved Centre Hills is the tourism industry. The majority of the tourists come to view the volcano and enjoy the natural beauty of the Centre Hills. The tourist exit survey clearly indicated the willingness of visitors to pay a tourist user fee – “Conservation Fee” – to go to Environmental Fund. This potential fund calls for the development of the most cost-effective way of extracting the fee (e.g. head tax, ticket/permit, etc.). The increasing international nature tourism in combination with the removal of several bottlenecks of the tourist sector in Montserrat (i.e. limited access to Montserrat) could lead to a further expansion of the tourist industry. It will be imperative to ensure that tourism in the Centre Hills is carefully managed to optimise benefits to livelihoods and to ensure that environmental impacts are within the limits of acceptable change.

### *Recommendations*

- Develop adequate facilities and infrastructure (e.g. trails, signage) and mechanisms (e.g. guidelines, standards, regulations, and certification for tour guiding, safety, visitor management and limits of acceptable change) to manage existing tourism in the Centre Hills and ensure its sustainability.
- Develop a marketing plan to promote use of the Centre Hills as a tourism attraction.
- Assess the potential for developing Centre Hills further as an attraction by improving the facilities and trails in the park and enhancing marketing of the site.
- Develop mechanisms to capture the economic benefits from tourism in the Centre Hills and feed these into management of the Centre Hills via use of the proposed Environmental Fund.
- Develop mechanisms and capacity for effectively and equitably sharing the benefits of tourism based on use of the Centre Hills to local communities, civil society organisations, and small businesses including through the development of downstream initiatives so that broader socio-economic benefits to the residents of Montserrat are ensured.
- Develop and implement monitoring systems to measure the use of the Centre Hills for tourism, the environmental and socio-economic costs and benefits of this use, and to ensure that it remains within the limits of acceptable change.

*Policy opportunities*

Specific policy guidance on management and development of tourism in the Centre Hills should be drawn from the existing policy framework in:

- The Sustainable Development Plan;
- The Physical Development Plan;
- The Centre Hills Management Plan; and
- The Tourism Strategic Plan.

*Institutional and capacity requirements*

There is currently inadequate capacity to effectively manage tourism in the Centre Hills. Presently, multiple stakeholders are playing a role. The institutional implications for effective management of tourism in the Centre Hills include the need for the development of MOUs to clarify roles, responsibilities, mechanisms for communication and collaboration between all agencies playing a role – the Montserrat Tourism Board, the Montserrat National Trust, the Department of Environment and Forestry, and other government agencies. The potential for additional use of existing capacity in the private sector and civil society, including in community-based organisations and the private sector, to undertake various management functions should be explored.

**15.3 Recommendations for the water sector**

Being the sole source of fresh water, the Centre Hills are crucial for Montserrat and this was identified as an extremely significant economic value provided by the Centre Hills. Several trends will increase this importance even further. The foreseen expansion in resident population of Montserrat in combination with a potential increase in visitor numbers will put more pressure on the current water supply. Moreover, climate change will also affect rainfall patterns in Montserrat, thereby increasing the water storage function of the Centre Hills. Another interesting development for the water sector in Montserrat is decreasing water quality and increasing scarcity of drinking water in the region. This implies a serious market potential for Montserrat as a water supplier.

*Recommendations*

- Develop a comprehensive water policy in Montserrat that will include consideration of the economic value of the watershed services being provided by the Centre Hills and the importance of protecting these services.
- Develop and implement mechanisms to capture economic benefits from watershed services provided by the Centre Hills and direct these funds into watershed management via the proposed Environmental Fund. As a first measure, with the increasing interest in moving to cost recovery, the water bill for households and companies in Montserrat should reflect actual cost. A portion of the water bill could be earmarked for watershed management (PWS). In addition, water-bottling companies should pay a levy proportional to their use.
- Explore the potential export market for water. If such market could be developed, an earmarked levy should be introduced for the extraction of water in the Centre Hills.

- Develop an eco-hydrological model for the Centre Hills to assist with developing a complete and accurate understanding of the economic value of watershed services provided by the Centre Hills.
- Monitor the costs and benefits flowing from watershed services of the Centre Hills and to feed these into cost pricing.

*Policy opportunities*

The current policy setting in Montserrat leaves ample space for the integration of a more comprehensive water management plan. Policies that such improved water strategy could link to are:

- The Sustainable Development Plan;
- The Physical Development Plan; and
- The Centre Hills Management Plan.

*Institutional and capacity requirements*

Currently, there is an informal management arrangement between the MWA and Forestry, but merger of utilities may imply the need for a MOU to formalise the concrete roles, responsibilities and mechanisms for communication and collaboration. It will be important to ensure that the MWA has the required capacity to develop a hydrological model and to effectively utilise this in water management. Capacity will also be needed to monitor the costs and benefits flowing from watershed services of the Centre Hills and to feed these into cost pricing.

**15.4 Recommendations on biodiversity and invasive species**

Despite the limited data on pig population size and dynamics (including impact of food supply on breeding rates), as well as the level of hunting of feral pigs, the economic valuation study has clearly shown that there is a high public concern about the danger of invasive species for damage to biodiversity and other ecosystem services of the Centre Hills. This justifies the current research activities, such as the rat control experiment, as well as more comprehensive studies on the costs of eradication and control techniques for invasive species in Montserrat.

*Recommendations*

- Conduct the required ecological and socio-economic studies to determine the extent of the invasive species problem, the ecological and socio-economic impact, and the potential control methods.
- Develop a range of potential control methods for feral pigs (including via managed over-hunting) and conduct a cost-benefit analysis of each to determine the most viable strategy for invasive pig control in Montserrat.
- Develop a Strategy and Action Plan for Invasive Control.
- Secure funds for the implementation of control measures for invasive species via the proposed Environmental Fund. An earmarked tax or a levy on hunting permits for pigs could be introduced. Alternatively, international partners (e.g. zoos) could adopt certain charismatic species.

*Policy opportunities*

The integration of invasive species control projects into current policies in Montserrat is not difficult. There are a number of policy opportunities for addressing the importance of action in this direction. These policy opportunities include:

- The Species Action Plans currently being developed;
- The National Environmental Management Strategy (NEMS);
- The Public Participation Policy;
- The Physical Development Plan;
- The Sustainable Development Plan;
- The Centre Hills Management Plan;
- The Tourism Strategic Plan;
- The Sustainable Livestock Production Programme.

*Institutional and capacity requirements*

Comprehensive action in the field of control of invasive species has a numerous institutional implications. More financial and human capital is needed to implement related activities. Preferably, this should be done in close collaboration with international partners (e.g. CABI, other islands) to utilise the foreign experience in invasive species. Under the leadership of the Department of Environment, other related government agencies would need to be involved.

**15.5 Conclusion**

Introducing the above-mentioned payments into the proposed Environmental Fund will ensure that beneficiaries of goods and services from the Centre Hills are contributing to the costs of management.

A Management Plan has been prepared for the Centre Hills and the cost of implementation estimated. The costs for Year 1 range from a maximum of US\$1.5 million to a minimum of US\$ 0.7 million, when non-essential activities are excluded. The costs of conserving the Centre Hills are therefore less than the economic benefits provided as tentatively estimated at around US\$1.4 million per year, with a minimum and maximum value of US\$0.9 million and US\$2 million per year, respectively.

By introducing the above mentioned payment mechanisms into the proposed Environmental Fund, the Centre Hills will come a step closer to a desperately needed system of sustainable financing. This will ensure that it can continue to protect the unique biodiversity found there as well as to provide the goods and services that are essential for socio-economic development in Montserrat.

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## Appendix I. Land ownership

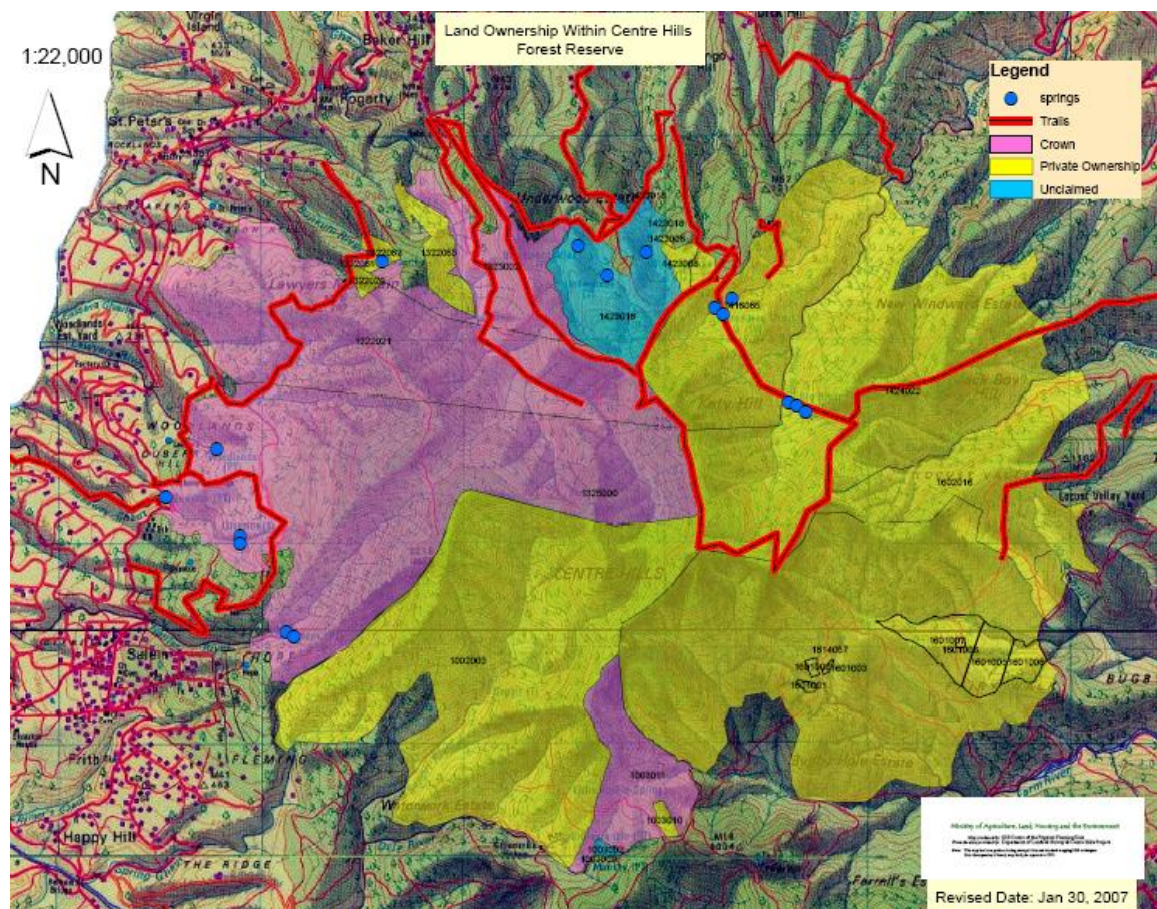


Figure I.1 Land ownership map of Centre Hills

Source: GIS Centre of the Physical Planning Unit / Department of Lands & Survey & Centre Hills Project (2007)

## Appendix II. Household questionnaire

### Centre Hills Economic Valuation Questionnaire

The main objective of this survey is to find out how important you consider the Centre Hills. There is no right or wrong answer to the questions: we only want your honest opinion.

This is an independent study and your answers and identity will be held in strict confidentiality. Your household was randomly selected to be part of the study. The survey will take about 25 minutes. We would like to request that only the male or female household head (adult) should answer this questionnaire: household members can help, but nobody outside the household should be involved in the interview.

Name interviewer	
Date	
Location	
Time start	
Time end	
Questionnaire number	

<b>Part 1: Opinion of Centre Hills</b>
--

1. How often do you visit the Centre Hills?
  - a. 10 times a year or more
  - b. 5 to 9 times a year
  - c. 1 to 4 times a year
  - d. Less than 1 time a year
  - e. Never
  - f. Other.....
  
2. If you do visit the Centre Hills, which activities do you participate in?
  - a. Hiking
  - b. Collecting fruit
  - c. Observing wildlife
  - d. Hunt mountain chickens
  - e. Fishing
  - f. Collect wood
  - g. Collect plants
  - h. Tend livestock
  - i. Farming
  - j. Other.....

Please answer to what extent you agree with the following statements:

3. With better trails and picnic sites, I would visit the Centre Hills more often
  - a. Strongly disagree
  - b. Disagree
  - c. No opinion
  - d. Agree
  - e. Strongly agree
  
4. I enjoy the natural beauty of the Centre Hills from a distance
  - a. Strongly disagree
  - b. Disagree
  - c. No opinion
  - d. Agree
  - e. Strongly agree

5. The natural beauty of the Centre Hills is an attraction for tourists
  - a. Strongly disagree
  - b. Disagree
  - c. No opinion
  - d. Agree
  - e. Strongly agree
6. The Centre Hills should be preserved for future generations
  - a. Strongly disagree
  - b. Disagree
  - c. No opinion
  - d. Agree
  - e. Strongly agree
7. The Centre Hills should be designated as a National Park, so that housing and agricultural development is restricted and low impact activities (e.g. recreation, collecting fruit) are allowed
  - a. Strongly disagree
  - b. Disagree
  - c. No opinion
  - d. Agree
  - e. Strongly agree
8. Montserrat's endangered species (e.g. Montserrat oriole, mountain chicken, Montserrat galliwasp) should be protected no matter what the financial cost
  - a. Strongly disagree
  - b. Disagree
  - c. No opinion
  - d. Agree
  - e. Strongly agree

9. Do you agree with the principle that the more water you use, the more you should pay?
  - a. Strongly disagree
  - b. Disagree
  - c. No opinion
  - d. Agree
  - e. Strongly agree
  
10. *[Record whether there is a direct view of the Centre Hills from the respondent's house]*
  - a. View of Centre Hills
  - b. No view of Centre Hills



**Part 2: Choice Experiment*****[Read this text]***

In the next questions, we will show you four cards. Each card presents two future options for the Centre Hills, and the current situation. These two options are possible management plans, which might be implemented in the future. You are asked to indicate which option you prefer most.

Each option is described by:

- Quality of forest cover
- Abundance of unique wildlife
- Extent to which invasive species are controlled
- Quality of trail maintenance
- Tax

We will now show you the four different cards. For each of the cards, could you indicate which option you prefer most. Note that the options may not represent your ideal situation, but we simply want you to choose between the options available.

**VERSION: ..... [very important!!!!]**

11. Card 1: choice made:

- a. A
- b. B
- c. Current situation

12. Card 2: choice made:

- a. A
- b. B
- c. Current situation

13. Card 3: choice made:

- a. A
- b. B
- c. Current situation

14. Card 4: choice made:

- a. A
- b. B
- c. Current situation

15. *[only ask this question if the respondent has chosen 'c. current situation' four times]*

You have chosen the current situation at each card, so four times. Can you explain

why?.....

.....

16. In making your choices, what was most important to you? As many items as you like can be indicated.

- a. I considered all items simultaneously
- b. I focussed mostly on forest cover
- c. I focussed mostly on wildlife
- d. I focussed mostly on invasive species
- e. I focussed mostly on trail maintenance
- f. I focussed mostly on tax

### **Part 3: Household information**

In this last part, you are asked several questions about your household's characteristics. We would like to remind you that we will treat your answers in strict confidentiality.

17. Were you born in Montserrat?

- a. Yes -> go to question 20
- b. No

18. If not born here, where were you born?

.....

19. If not born here, how long have you lived in Montserrat?

.....years

20. What is your age?

- a. 18-24 years
- b. 25-39 years
- c. 40-54 years
- d. 55-69 years
- e. 70 years or older

21. *[fill in the gender of the respondent*

- a. Male*
- b. Female]*

22. What is your highest educational attainment?

- a. No formal schooling
- b. Primary
- c. Secondary (o-level)
- d. Vocational
- e. University

23. Please list the number of household members per age group:

- a. Children (0-12 years of age): ....
- b. Teens (13-17 years of age): ....
- c. Adults (above 18 years of age): ....
- d. *Total household members:* ....

24. What is your total household income per month?

- a. Less than \$500
- b. \$500-999
- c. \$1,000-2499
- d. \$2500-4999
- e. More than \$5000

25. What are your sources of income? Indicate as a percentage (%) of total income

<b><i>How much of your total household income comes from:</i></b>	<b><i>%</i></b>
a. Public sector permanent	
b. Private sector permanent	
c. Temporary wage labour	
d. Own business	
e. Land rent	
f. Remittances from family	
g. Agriculture farming	
h. Agriculture livestock	
i. Fisheries	
j. Pension	
k. Other, please specify:	

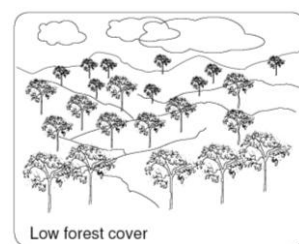
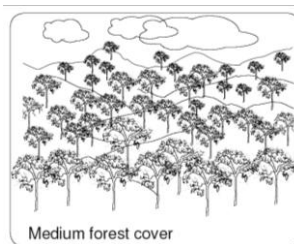
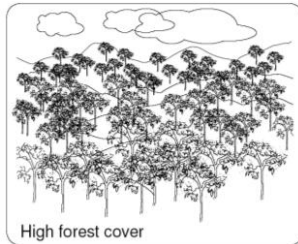
**THANK YOU FOR YOUR COOPERATION**

*[Please note down any remarks of the respondent]*

## Explanation attributes

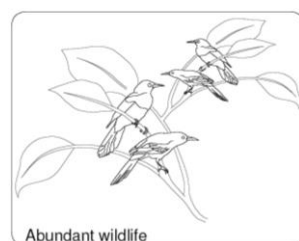
### Quality of forest cover

Montserrat is also called the 'Emerald island' because of its green forests. The quality of forest cover in the Centre Hills creates an important part of the natural beauty of the island. In the current situation, the forest cover of the area is high. This could change in the future to medium or low forest cover as a result of for example the increase of human activities and/or a lack of management.



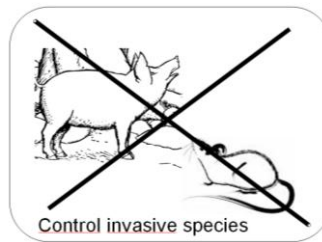
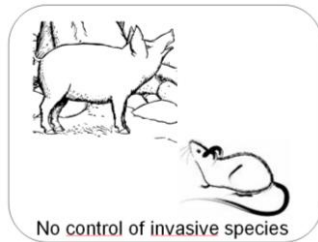
### Abundance of unique wildlife

Montserrat is home to a number unique wildlife species, such as the Montserrat oriole, the mountain chicken and the Montserrat galliwasp. However, these species are currently endangered and could even go extinct. On the other hand, these species could become more abundant in the future if human activities are regulated and the area is properly managed.



### Extent to which invasive species are controlled

On Montserrat, invasive species such as pigs and rats are having large impacts on the forest and its native wildlife. These animals are for example eating bird eggs or destroying the forest grounds in the Centre Hills. In the current situation, invasive species are not being controlled. To reduce the impact of invasive species, they could be controlled in the future.



### Quality of trail maintenance

There are a number of trails running through the Centre Hills forest that are used by locals and visitors for hiking and viewing wildlife and the forest itself. Currently the trails are of medium quality but could be improved with greater trail maintenance. Alternatively the trails could disappear if they are not maintained at all, which would make hiking in the Centre Hills impossible.



### Tax

In order to pay for the maintenance and proper management of the Centre Hills forest the government would need to raise funds. This could be done through a small increase in income tax that is paid by everyone. The extra income tax that you would pay per month could be EC\$10, 20, or 30.

## Appendix III. Principles of choice modelling

The theoretical basis for stated choice research lies in random utility theory in which a person's utility from a particular site or experience is described by the following utility function (sometimes referred to as a conditional indirect utility function):

$$U_{in} = V_{in} + \varepsilon_{in}. \quad (1)$$

The utility gained by person  $n$  from alternative  $i$  is made up of an objective or deterministic and observable component ( $V$ ) and a random, unobservable component ( $\varepsilon$ ) (Adamowicz *et al.*, 1994, 1998).

The observable component of utility ( $V$ ) can be expanded as follows:

$$V_{in} = ASC_i + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k. \quad (2)$$

$ASC_i$  is an alternative-specific constant which represents the “mean effect of the unobserved factors in the error terms for each alternative” (Blamey *et al.*, 1999, p. 341). The  $X_k$  values are associated with each attribute level used in the choice experiment, while the  $\beta_k$  coefficients are included to capture the corresponding part-worth utility associated with each attribute level for all  $k$  attributes.

An individual will choose alternative  $i$  over alternative  $j$  if and only if the total utility associated with alternative  $i$  is greater than alternative  $j$  or  $U_{in} > U_{jn}$ . The probability that person  $n$  will choose alternative  $i$  over alternative  $j$  is given by the equation:

$$\text{Prob}(i|C) = \text{Prob}\{V_{in} + \varepsilon_{in} > V_{jn} + \varepsilon_{jn}; \forall j \in C\}, \quad (3)$$

where  $C$  is the complete set of all possible options from which the individual can choose.

The unobservable component  $\varepsilon$ , often referred to as a random error component, is commonly assumed to be type I or Gumbel distributed and to be independently and identically distributed (McFadden, 1974).

If the  $\varepsilon$  term is assumed to be Gumbel-distributed, the probability of choosing alternative  $i$  can be calculated by the equation (McFadden, 1974):

$$\text{Prob}(i) = \frac{\exp^{\mu v_i}}{\sum_{j \in C} \exp^{\mu v_j}}, \quad (4)$$

which represents the standard form of the multinomial logit model (MNL).

Although the MNL is the most common form applied to the analysis of discrete choice data due to its robustness and simplicity associated with calculating the probabilities (Louviere *et al.* 2000), other models are also regularly used in stated choice research (e.g. the probit model). An important outcome of the logit model is that choices are assumed to be independent of irrelevant alternatives (IIA), meaning that “the ratio of choice probability for any two alternatives is unaffected by addition or deletion of alternatives” (Carson *et al.*, 1994, p. 354). In other words, the alternatives are assumed to be independent.

The  $\beta_k$  coefficients (or part-worth utilities) are derived by fitting the choice model to the observed data on the stated choice probabilities (aggregated over all respondents) and the

experimental design used to define the attribute levels seen by respondents for each choice set. Choice models are usually estimated using maximum likelihood analysis.

To calculate efficient part worth utilities, the choice experiments are normally designed to ensure orthogonality<sup>9</sup> of attribute levels both within and between alternatives. A full factorial design where all main effects and interactions are orthogonal represents one extreme. However, full factorial design plans require individuals to evaluate an unrealistic number of choice sets (e.g. every possible combination of attribute levels), even in cases where the total number of attributes is small. Therefore, researchers typically make trade-offs between the ability of a design plan to estimate all possible interactions and the necessity of limit evaluation to a reasonable number of choice sets by employing a fractional factorial design plan. Fractional factorial designs typically permit the orthogonal estimation of all main effects and at least some interactions between the attributes.

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<sup>9</sup> In an orthogonal design, the attribute levels are uncorrelated with any other attributes, thus ensuring that the part worth utilities measure only the intended attribute and are not confounded with other attributes.

## Appendix IV. Results household survey

In this section, the results of the choice experiment survey are presented. First, socio-economic and demographic characteristics of the respondents are discussed. This is followed by the survey results of the respondents' perceptions of the Centre Hills, including the number of times people visit the area and the reasons for their visits.

### Nationality

From the 342 respondents, 72% were born on Montserrat. This means that the remaining 28% of the sample is non-national. This is different from the census data of 2001, in which 82% of population was national and 18% non-national<sup>10</sup>. As shown in Table 15.1, the majority of the non-nationals were born in Guyana (13.7%), followed by Dominica and Jamaica (each 2.6%). The average number of years that non-nationals have lived on Montserrat is 11.

*Table 15.1 Country of origin*

Country of origin	Number of respondents	
	#	%
Antigua	3	0.9%
Aruba	2	0.6%
Dominica	9	2.6%
Guyana	47	13.7%
India	4	1.2%
Jamaica	9	2.6%
Nevis	1	0.3%
Santa Domingo	1	0.3%
St. Kitts	2	0.6%
St. Lucia	2	0.6%
St. Vincent	5	1.5%
Trinidad	1	0.3%
UK	4	1.2%
USA	7	2.0%
Total	342	100%

### Gender and age

47% of the respondents were male and 53% were female. This is different from the census data of 2001, in which 55% of the population were male and 45% female.

The average age of the respondents is estimated to be 44 years old. The distribution among the different age groups is shown in Table 15.2. The majority of the respondents is between 25 and 39 years old (36%). A share of 35% falls in the category 40-54 years old, followed by 19% of the respondents that are between 55 and 69 years old.

<sup>10</sup> It should be noted that differences between the survey results and the census data from 2001 are likely to be expected, because the population has changed considerably in the last seven years (pers. comm. S. Mendes, December 2007).



Table 15.2 Age distribution

Age	Number of respondents		Census 2001
	#	%	% of total population $\geq$ 18 years*
18-24 years	21	6%	10%
25-39 years	122	36%	32%
40-54 years	118	35%	29%
55-69 years	63	19%	17%
70 years or older	16	5%	13%
Total	340	100%	100%
Missing	2		

\* The total population with an age of 18 years or older was 3,272.

The age distribution differs from the census data of 2001. In the youngest and oldest age categories, the share of the respondents is lower compared to the age distribution of the census. The percentages of respondents in the middle three categories are higher.

## Education

Table 15.3 shows the level of education reached by the majority of the respondents (38%) is secondary school. A relatively high percentage of the respondents (27%) have attended university. Compared to the census data, this share is 20% higher. Overall, the level of education of the survey respondents is higher than the population of 2001. Only the share of respondents that reached primary school is lower. As in the census data, all respondents in the sample attained at least primary school education.

Table 15.3 Level of education

Level of education	Number of respondents		
	#	%	% of total population (4,465)
No formal schooling	0	0%	0%
Primary	69	20%	34%
Secondary (o-level)	128	38%	27%
Vocational	52	15%	8%
University	91	27%	7%
Total	340	100%	100%
Missing	2		

## Household income

The average number of household members is 2.8 (compared to 2.1 in the census data of 2001). Most children (74% of a total of 304 within all households) are between the age of 0 and 12. A share of 32% of the respondents is alone or single parents.

Finally, 97% of the respondents chose to disclose information about their income and sources of income, which is representative of the entire population. The distribution for level of income is presented in Table 15.4. It shows that the majority of the respondents (37%) have a household income between EC\$ 2500 and EC\$ 4999 per month. A share of 30% of the respondents has a household income of more than EC\$ 5000 per month. Only

1% has an income level of less than EC\$ 500. Based upon respondent's information, the average household income is estimated at approximately EC\$3400 per month.

*Table 15.4 Household income (EC\$/month)*

Income level	Number of respondents	
	#	%
Less than \$500	4	1%
\$500-999	30	9%
\$1000-2499	76	23%
\$2500-4999	124	37%
More than \$5000	99	30%
Total	333	100%
Missing	9	3%

Respondents were asked to indicate their sources of income as a percentage of their total household income. The average of this share among the respondents is shown in Table 15.5 (per source of income). Respondents gain most of their income through the public sector (on average 39.3%), followed by the private sector (on average 38.5%). An average share of 9.5% of the respondents' income results from their own business and 7.8% from pension or social security. None of the respondents reported tending livestock as a source of income.

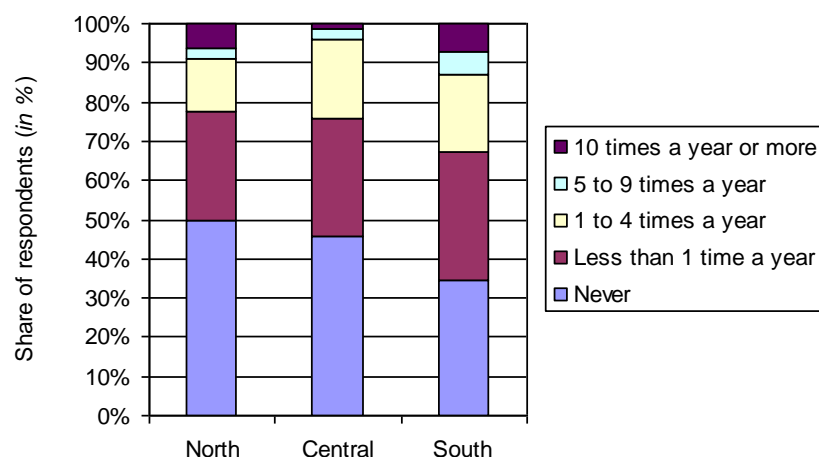
*Table 15.5 Sources of income*

Source of income	Average share of total household income
Public sector	39.3%
Private sector	38.5%
Temporary wage labour	1.3%
Own business	9.5%
Land rent	0.1%
Remittances from family	0.2%
Agriculture farming	0.7%
Agriculture livestock	0%
Fisheries	0.4%
Pension / social security	7.8%
Other	0.6%

### Perceptions of the Centre Hills

The majority of the respondents (60%) have a view of the Centre Hills from their house. The remainder 40% does not have a view of the Centre Hills. 43% of respondents report that they never visit the area, 30% visits the Centre Hills less than one time a year, 17% one to four times a year, 4% four to nine times a year and 6% goes 10 times a year or more. On average, this means that respondents visit the Centre Hills 1.7 times a year. It is interesting to see the differences among the respondents in the three geographical regions. People from the south visit the Centre Hills most (on average 2.1 times a year), followed by people from the north (1.6 times a year). People from the central part of the island visit the area least (1.2 times a year). Figure 1 presents the share of the

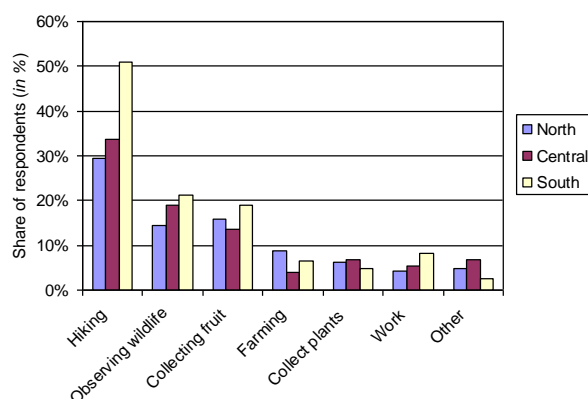
respondents in the different classes of visit frequency, separated per region. A share of 50% of the respondents from the north never visits the Centre Hills, while in the south this share is 34%. The highest share of respondents that visit the area more than 10 times year is from the south (7%), while this share is only 1% among respondents from the central part of the island.



*Figure 1 Visit frequency of respondents*

Respondents were also asked to indicate their reasons for visiting the Centre Hills. The majority of the respondents visit the Centre Hills to go hiking (38%). In addition to hiking activities, respondents engage in several other activities. These include, observing wildlife (18%), collecting fruit (16%), farming (7%), collecting plants (6%), work (for example control of the water springs) (6%), fishing (2%), tending livestock (1%), collecting wood (1%) and other activities (1%).

Again a division is made between respondents in the different regions. Here, all activities in which less than 5% of the respondents participate in are categorized as 'other'. These results are presented in Figure 2. The largest share of the respondents from the south participate in hiking (51%), observing wildlife (21%), collecting fruit (19%) and work related activities (8%). More respondents from the north (9%) participate in farming than in the other two regions and the largest share of respondents from the centre collect plants and participate in other activities (both 7%).



*Figure 2 Reasons for visiting Centre Hills*

In order to give more insight into people's perceptions of the Centre Hills, respondents were asked to what extent they agreed with seven statements. The results of the answers to the statements are shown in Figure 3. The majority of the respondents agree or strongly agree with each of the statements. The results are summarized as follows:

- 37% of the respondents agree and 60% strongly agree with the statement "the Centre Hills should be preserved for future generations"
- 58% of the respondents agree and 37% strongly agree with the statement "the natural beauty of the Centre Hills is an attraction for tourists"
- 50% of the respondents agree and 42% strongly agree with the statement "Montserrat's endangered species (e.g. Montserrat oriole, mountain chicken, Montserrat galliwasp) should be protected no matter what the financial cost"
- 60% of the respondents agree and 34% strongly agree with the statement "I enjoy the natural beauty of the Centre Hills from a distance"
- 57% of the respondents agree and 30% strongly agree with the statement "With better trails and picnic sites, I would visit the Centre Hills more often"
- Although, approximately 10% of the respondents disagrees with the statement that the area should be designated as a national park in which agriculture and housing are restricted, the majority still agrees with this statement (55% agrees and 27% strongly agrees)
- The statement "the more water you use, the more you should pay" resulted in the most disagreement. 5% strongly disagrees and 29% disagrees, compared to 51% that agrees

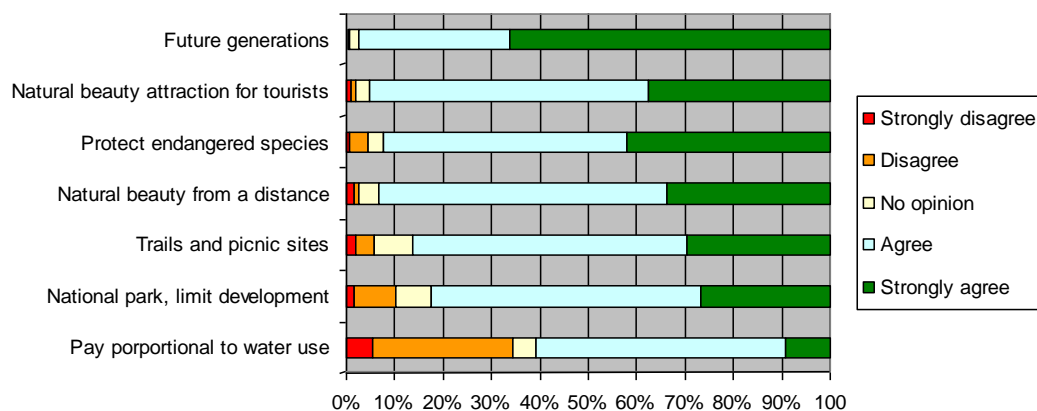


Figure 3 Perception of households regarding statements about Centre Hills

## Appendix V. Species abundance in Montserrat

The Biodiversity Assessment Report (CHBA) (Young ed., 2008) has revealed detailed information about the importance of the Centre Hills' biodiversity. There are currently 941 plant species known on Montserrat. Of these, 795 are native plant species, 70 are endemic to the Lesser Antilles, and another five species' ranges exceed the Lesser Antilles but are restricted to a small area outside the Lesser Antilles. Three plant species have been identified as strictly endemic to Montserrat: the shrub species *Rondeletia buxifolia*, the orchid species *Epidendrum montserratense* and the small tree species *Xylosma serratum*. The CHBA has produced evidence that the first two species will qualify as Critically Endangered (i.e. "at extremely high risk of extinction in the wild"), the highest level of threat as assessed by the World Conservation Union (IUCN).

Potentially, Montserrat is home to 78 plant species of global conservation concern. A number of 1,241 recognised invertebrate species occur in Montserrat, including 718 known beetle species from 63 families. The majority of these invertebrate species are probably only found in the Centre Hills forest. Roughly 120 invertebrate species have been identified as being possibly unique to Montserrat.

Three species of amphibian and 11 terrestrial reptiles have been recorded to occur on Montserrat. Six reptiles, at both species and sub-species level, are endemic to Montserrat. This means that this group has highest endemism of all vertebrate animal and plant taxa on the island. Montserrat can be considered to have high herptile species richness, which is probably due to high habitat diversity. Amongst these species are the extremely rare and almost unknown Montserrat galliwasp (*Diploglossus montisserrati*) and the mountain chicken frog (*Leptodactylus fallax*) (the second largest frog species of the world). Both species are listed as Critically Endangered.

The bird community of the Centre Hills is species-poor, but of high conservation value. Twelve restricted-range bird species are listed for Montserrat<sup>11</sup>. The Centre Hills supports the world's largest population of the endemic IUCN-listed Critically Endangered Montserrat oriole (*Icterus oberi*) and Vulnerable forest thrush (*Cichlerminia lherminieri*).

Finally, ten species of bat occur on Montserrat. Two of these species are classified as Endangered: the white-lined bat (*Chiroderma improvisum*) and the yellow shouldered volcano bat (*Sturnira thomasi vulcanensis*). The latter is an endemic subspecies.

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<sup>11</sup> Restricted-range species are those that only occur in the Lesser Antilles and immediate surrounding area (Young ed., 2008).

## Appendix VI. Costs of pig control

Table VI.6 Cost estimates of pig control programme

Item	Unit	Quantity	Unit cost EC\$	Total cost EC\$
<i>Personnel</i>				
Director of Agriculture (1)	Person days	50	225	11,250
Field Coordinator (1)	Person days	100	170	17,000
Shooters (3)	Person days	600	150	90,000
Dog Handlers (6)	Person days	900	150	135,000
Extension Officer (1)	Person days	50	170	8,500
Pig Eradication Specialist	Person days	60	1,350	81,000
<i>Equipment</i>				
Radio tracking collars/tags	collars or tags	5		
Radio tracking receivers	Receiver	2		
GPS	Receiver	3	1,200	3,600
Firearms	Guns	3	700	2,100
Ammunition	Rounds	4000	3	12,000
Field clothing (boots, raincoat)	Person outfits	9	350	3,150
Rope	Feet	200	3	600
Trail clearing gear (cutlasses, files, knives)	Person kits	9	75	675
First aid kits	Team kits	3	150	450
Snares	Snares	15	200	3,000
<i>Travel and subsistence</i>				
Travel allowance	Team days	200	10	2,000
Overseas travel	Trips	4	4,000	16,000
Accommodation	Nights	40	150	6,000
Per diem	Days	40	150	6,000
<i>Administration and management</i>				
Communications (phone, Internet, etc)	Months	24	1,000	24,000
<i>Consumables and sundries</i>				
Data recording gear (note books, etc)	Team kits	3	500	1,500
<i>Monitoring and evaluation</i>				
Monitoring gear				0
<i>Reporting and publicity</i>				
Report production	Reports	10	50	500
<b>Total</b>				<b>424,325</b>

## Appendix VII. EVP Exit survey

### TO BE COMPLETED BY VISITORS TO MONTSERRAT (including persons spending less than 6 months per year in Montserrat)

*Dear Visitor – This anonymous survey will inform about recreational activity patterns on Montserrat. The results of the survey will be used to guide management of the Centre Hills. Your participation is greatly appreciated. Please take a few moments to complete the survey and drop it in the designated box. Thank you.*

- 1.) What is today's date? \_\_\_\_\_
- 2.) The primary purpose of my visit was (tick one)    ☐ Business    ☐ Leisure
- 3.) Including yourself, how many people are travelling in your party? \_\_\_\_\_
- 4.) Where do you live right now? Circle one.    USA    UK    Canada    Caribbean    Other (specify) \_\_\_\_\_
- 5.) On this visit, how long did you stay in Montserrat?    ☐ 1 to 3 days    ☐ 4 to 7 days    ☐ 1 to 2 weeks  
Tick one.    ☐ 3 to 4 weeks    ☐ 1 to 3 months    ☐ 4 to 6 months
- 6.) What were the reasons that you chose to come to Montserrat? Tick all that apply.

<i>Activity</i>	<i>Major reason for coming</i>	<i>Minor reason for coming</i>	<i>Did not factor into my decision</i>
Natural environment / wildlife viewing	_____	_____	_____
Hiking	_____	_____	_____
Volcano viewing	_____	_____	_____
Visit friends/family	_____	_____	_____
Family/friend recommendation	_____	_____	_____
Uncrowded destination	_____	_____	_____
Snorkeling/SCUBA diving	_____	_____	_____
Own property	_____	_____	_____
Other _____	_____	_____	_____

- 7.) What sources of information were important in planning your trip to Montserrat? Tick all that apply.

<input type="checkbox"/> Brochure	<input type="checkbox"/> Newspaper/magazine	<input type="checkbox"/> Internet
<input type="checkbox"/> Guide book	<input type="checkbox"/> TV / Radio	<input type="checkbox"/> Friends/family
<input type="checkbox"/> Previous visit	<input type="checkbox"/> Other (please list) _____	

- 8.) What activities you engaged in during your stay? Tick all that apply.

<input type="checkbox"/> Hiking	<input type="checkbox"/> Wildlife viewing
<input type="checkbox"/> Snorkelling / SCUBA diving	<input type="checkbox"/> Going to the beach
<input type="checkbox"/> Visit to Jack Boy Hill viewing platform	<input type="checkbox"/> Visit to Montserrat National Trust
<input type="checkbox"/> Visit to MVO	<input type="checkbox"/> Visit to exclusion zone
<input type="checkbox"/> Fishing	<input type="checkbox"/> Other: _____

- 9.) If you spent any time hiking during your visit, which trails (or what area) did you visit? Tick all that apply.

<input type="checkbox"/> Rendezvous	<input type="checkbox"/> Katy Hill	<input type="checkbox"/> Jack Boy Hill
<input type="checkbox"/> Oriole Walkway	<input type="checkbox"/> Blackwood Allen	<input type="checkbox"/> Duberry / Cassava
<input type="checkbox"/> Runaway Ghaut	<input type="checkbox"/> The Cot	<input type="checkbox"/> Other: _____

- 10.) If you did hike, how did you hear about hiking opportunities? Please tick all that apply.

<input type="checkbox"/> Montserrat National Trust	<input type="checkbox"/> Taxi driver / tour guide
<input type="checkbox"/> Brochure / trail map	<input type="checkbox"/> Guide book
<input type="checkbox"/> Family/friends	<input type="checkbox"/> Newspaper / media
<input type="checkbox"/> Internet	<input type="checkbox"/> Other (please state who or where) _____
<input type="checkbox"/> Montserrat Tourist Board	_____

- 11.) Did you hire a trail guide to take you hiking? \_\_\_\_ Yes \_\_\_\_ No
- If so, where did you hire your trail guide? \_\_\_\_\_
- What was the duration of your guided hike? \_\_\_\_\_
- If you paid a fee for your trail guide, what was the cost per person (in US\$)? \_\_\_\_\_
- What did the fee include? Tick all that apply. \_\_\_\_ Transportation \_\_\_\_ Meals/refreshments  
\_\_\_\_ Guided hike \_\_\_\_ Other (specify) \_\_\_\_\_
- 12.) Please rate how your expectation (before your trip) met with your actual experience (at the end of your trip).  
Tick one box for each statement.
- | Activity                                    | Better than<br>expected | Same as<br>expected | Worse than<br>expected | Not applicable |
|---|-------------------------|---------------------|------------------------|----------------|
| a. Opportunity to view plants and animals   | _____                   | _____               | _____                  | _____          |
| b. Abundance of plants and animals          | _____                   | _____               | _____                  | _____          |
| c. Sense of being in a pristine environment | _____                   | _____               | _____                  | _____          |
| d. Access to trails (roads, parking)        | _____                   | _____               | _____                  | _____          |
| e. Condition of trails                      | _____                   | _____               | _____                  | _____          |
| f. Difficulty of trails                     | _____                   | _____               | _____                  | _____          |
| g. Interpretation (signs, maps, leaflets)   | _____                   | _____               | _____                  | _____          |
| h. Interaction/knowledge of trail guide     | _____                   | _____               | _____                  | _____          |
| i. Value for the price of trail guide       | _____                   | _____               | _____                  | _____          |
| j. Presence of parks or protected areas     | _____                   | _____               | _____                  | _____          |
| k. Cleanliness of natural areas             | _____                   | _____               | _____                  | _____          |
| l. Safety of the hiking experience          | _____                   | _____               | _____                  | _____          |
- 13.) Given the natural environment, what sorts of recreational services and/or facilities would you personally use in a national park in Montserrat? Tick all that apply.
- \_\_\_\_ Public restrooms      \_\_\_\_ Guided hiking trails (fee required)  
 \_\_\_\_ Overnight camping      \_\_\_\_ Food concession  
 \_\_\_\_ Picnic facilities      \_\_\_\_ Wildlife viewing platforms  
 \_\_\_\_ Interpretation centre      \_\_\_\_ Other (specify) \_\_\_\_\_  
 \_\_\_\_ Self-guided hiking trails
- 14.) How much would you be willing to pay for entrance to a national park in Montserrat if it contained the amenities you have listed above? Tick one.
- \_\_\_\_ Would not be willing to pay      \_\_\_\_ US\$15 person/day      \_\_\_\_ US\$100 person for an annual pass  
 \_\_\_\_ US\$5 person/day      \_\_\_\_ US\$20 person/day      \_\_\_\_ US\$250 person for an annual pass  
 \_\_\_\_ US\$10 person/day      \_\_\_\_ US\$25 person/day      \_\_\_\_ Other (specify) \_\_\_\_\_

***Thank you for your participation. Please come again!***

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